This traveler is intended to document the checking of the final magnetic measurements of an Undulator Segment performed on the Kugler bench in the Magnetic Measurement Facility (MMF) at SLAC after the completion of the tuning process. It contains basic performance indicators compared against tolerances as well as documentary information both in graphical and textual representation.

Serial number from magnet label:	29A804-023
Device name from magnet label:	HE_SXU_023

Measurement Procedure:

The measurements have been carried out after the undulator segment had been fully tuned according to the "LCLS-II-HE Undulator Test Plan" (LCLS-TN-22-9).

Evaluation of Hall Probe Scans: Data Listings A

MATLAB function "EvaluateUndulatorField" on	08/13/2024 17:40	
A. SCAN PARAMETERS		
z Scanning Date & Time Range	08/01/2024 14:02 - 08/02/2024 14:24	
Undulator Temperature	20.0374±0.0065	°C
x axis position	-0.075943	mm
y axis position	0.000303	mm
Total number of poles per strongback	122	
Number of full field poles	116	
Number of core poles	108	
First core pole #	8	
Last core pole #	115	
Average λ_u	55.998	mm
Standard deviation from average λ_u	38.9	μm
Average k_u	112.204	m^{-1}
Scans averaged	3	
Nominal Tuning Gap	10.0000	mm
Nominal Commissioning Gap	16.5800	mm

Evaluation of Hall Probe Scans at Tuning Gap: Data Listing B

MATLAB function "EvaluateUndulatorField" on	08/13/2024 17:40	
B. CORE EVALUATIONS FOR TUNING GAP		
Tuning Gap Scanning Date & Time Range	08/01/2024 20:42	
Actual Tuning Gap	10.0002	mm
Tuning Gap Temperature	+20.048±0.028	°C
Planar Hall Effect Correction Range	0.750200 - 4.150200	m
Planar Hall Effect x Corr Function	+0.20 G + (z - 0.750200 m)×0.12 G/m	
Planar Hall Effect y Corr Function	-0.07 G + (z - 0.750200 m)×0.09 G/m	
Coil Range	0.650210 - 4.250210	m
$\langle\lambda_u\rangle$	+55.998±0.017	mm
$\langle k_u\rangle$	+112.204±0.034	1/m
$\langle K_u\rangle$	+7.2892±0.0062	
K_{eff} @ Tuning Temperature	+7.28683±0.00011	
L_{eff}	+3.300595±0.000098	m
$L_{2\pi}$	+1.54268±0.00048	m
I1X (Cell Range Total)	+8.34	μTm
I2X (Cell Range Total)	+76.13	μTm^2
I1Y (Cell Range Total)	+5.42	μTm
I2Y (Cell Range Total)	-11.45	μTm^2
PI (Cell Range Total)	254,587.9	T^{2}mm^3
Phase Shake	1.04	degXray
Cell Phase Advance (over 4.400000 m)	21,475.5 (60×360-124.5)	degXray
Undulator Entrance Phase	+1018.19±1.00	degXray
Undulator Exit Phase	+1017.35±1.00	degXray
Undulator Phase Imbalance: Entrance - Exit	+0.8±1.4	degXray
Cell Entrance min. Phase Shifter Correction	61.8	degXray
Cell Exit min. Phase Shifter Correction	62.6	degXray

Evaluation of Hall Probe Scans at Commissioning Gap: Data Listing C

MATLAB function "EvaluateUndulatorField" on	08/13/2024 17:40	
C. CORE EVALUATIONS FOR COMMISSIONING GAP		
Commissioning Gap Scanning Date & Time Range	08/01/2024 20:42	
Actual Commissioning Gap	16.5804	mm
Commissining Gap Temperature	$+20.048\pm0.028$	°C
Planar Hall Effect Correction Range	0.750200 - 4.150200	m
Planar Hall Effect x Corr Function	-0.06 G + (z - 0.750200 m)×0.07 G/m	
Planar Hall Effect y Corr Function	+0.34 G + (z - 0.750200 m)×-0.21 G/m	
Coil Range	0.650238 - 4.250238	m
$\langle\lambda_u\rangle$	$+55.998\pm0.015$	mm
$\langle k_u\rangle$	$+112.205\pm0.030$	1/m
$\langle K_u\rangle$	$+4.2903\pm0.0035$	
K_{eff} @ Tuning Temperature	$+4.289933\pm0.000064$	
L_{eff}	$+3.309204\pm0.000099$	m
$L_{2\pi}$	$+0.57127\pm0.00015$	m
I1X (Cell Range Total)	+8.80	μTm
I2X (Cell Range Total)	+70.33	μTm^2
I1Y (Cell Range Total)	+9.79	μTm
I2Y (Cell Range Total)	+80.78	μTm^2
PI (Cell Range Total)	88,469.4	T^{2}mm^3
Phase Shake	1.50	degXray
Cell Phase Advance (over 4.400000 m)	21,961.8 (61×360+1.8)	degXray
Undulator Entrance Phase	1261.4 (7×180+1.4)±1.5	degXray
Undulator Exit Phase	1260.3 (7×180+0.3)±1.5	degXray
Undulator Phase Imbalance: Entrance - Exit	$+1.1\pm2.1$	degXray
Cell Entrance min. Phase Shifter Correction	$+178.6\pm1.5$	degXray
Cell Exit min. Phase Shifter Correction	$+179.7\pm1.5$	degXray

Undulator Encoder Settings: Data Listing D

MATLAB function "EvaluateUndulatorField" on 08/13/2024 17:45

D. ENCODER SETTINGS

Upstream Gap Encoder Line Spacing	-20,000.0	EncoderCounts/mm
Upstream Scaled Gap Encoder Offset	228.4400	mm
Downstream Gap Encoder Line Spacing	-20,000.0	EncoderCounts/mm
Downstream Scaled Gap Encoder Offset	228.0665	mm
Upstream Scaled Top Motor Encoder Offset	-101.0855	mm
Downstream Scaled Top Motor Encoder Offset	-101.0133	mm
Upstream Half Gap Encoder Line Spacing	20,000.0	EncoderCounts/mm
Upstream Half Gap Encoder Offset	-32.9860	mm
Downstream Half Gap Encoder Line Spacing	20,000.0	EncoderCounts/mm
Downstream Half Gap Encoder Offset	-33.5589	mm

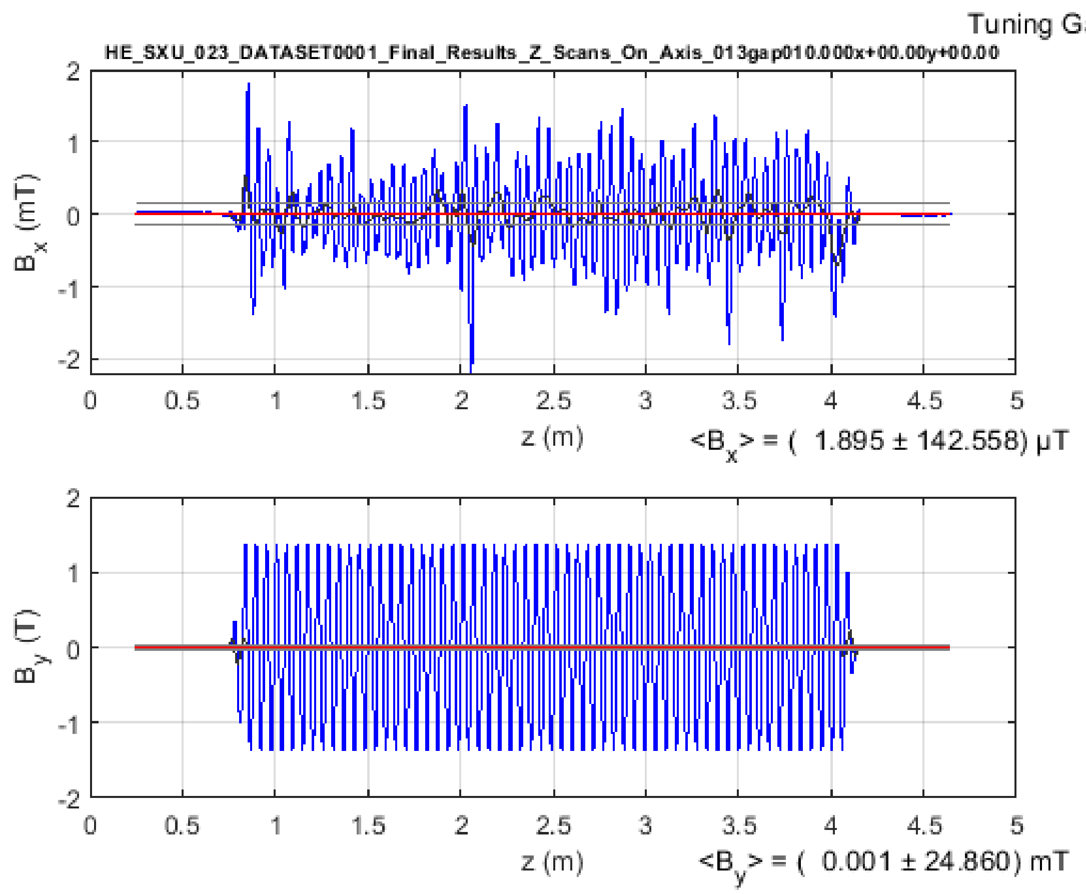
Undulator Capacitive Sensor Values: Data Listing E

E. CAPACITIVE SENSOR VALUES

Module	Pole	Capacitive Sensor Gap	Upstream Encoder	Downstream Encoder	
Ref	—	46.2242	50.0001	50.0003	mm
Ref	—	46.2243	50.0001	50.0003	mm
1	10	46.4997	46.4999	46.4999	mm
1	10	46.4996	46.4999	46.4999	mm
1	15	46.4984	46.4999	46.4999	mm
1	15	46.4983	46.4999	46.4999	mm
3	25	46.4826	46.4999	46.4999	mm
3	25	46.4825	46.4999	46.4999	mm
3	30	46.4829	46.4999	46.4999	mm
3	30	46.4829	46.4999	46.4999	mm
Ref	—	46.2226	49.9999	49.9999	mm
Ref	—	46.2228	49.9999	49.9999	mm

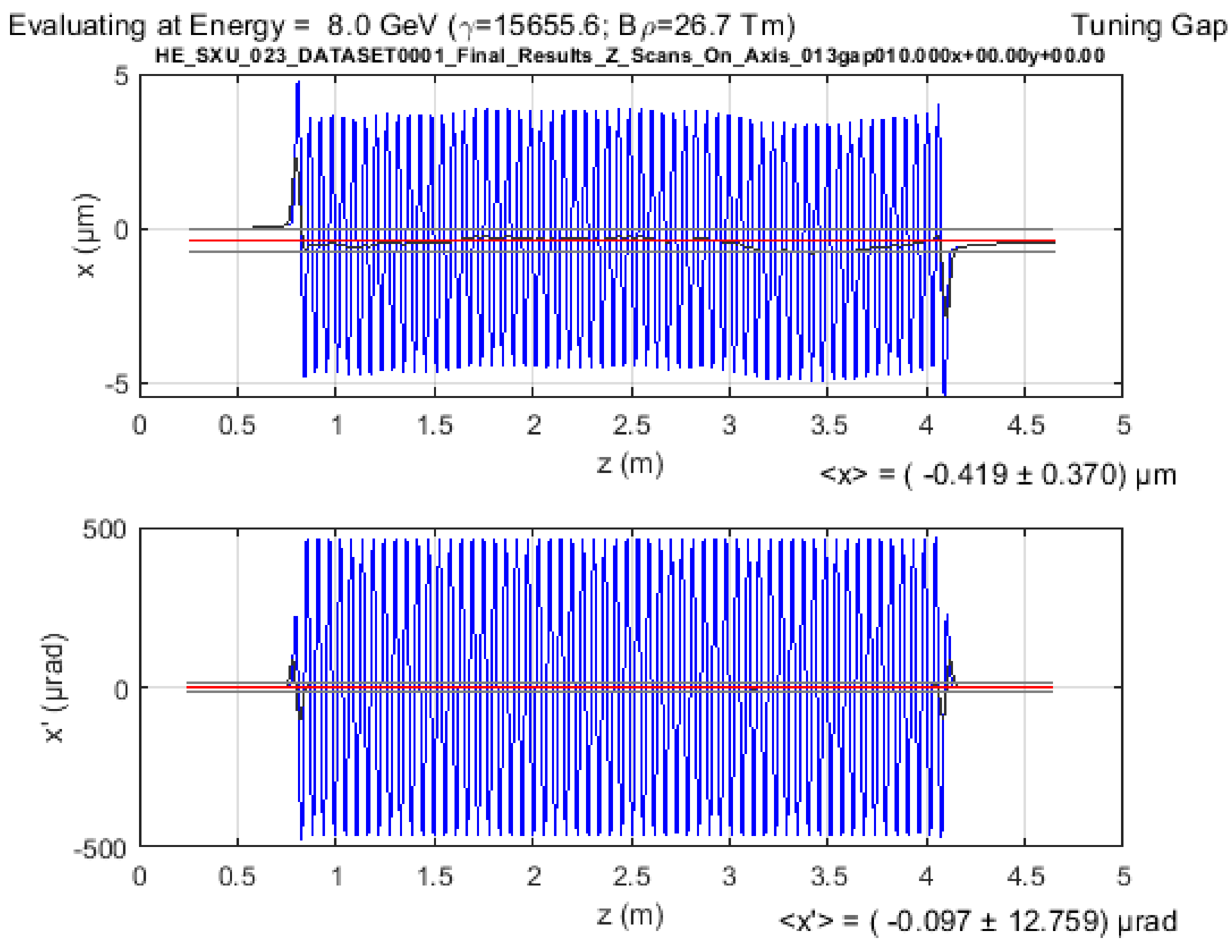
The following figures show results of the field analysis at the tuning gap.

Evaluation of Hall Probe at Tuning Gap: B_x & B_y Plot



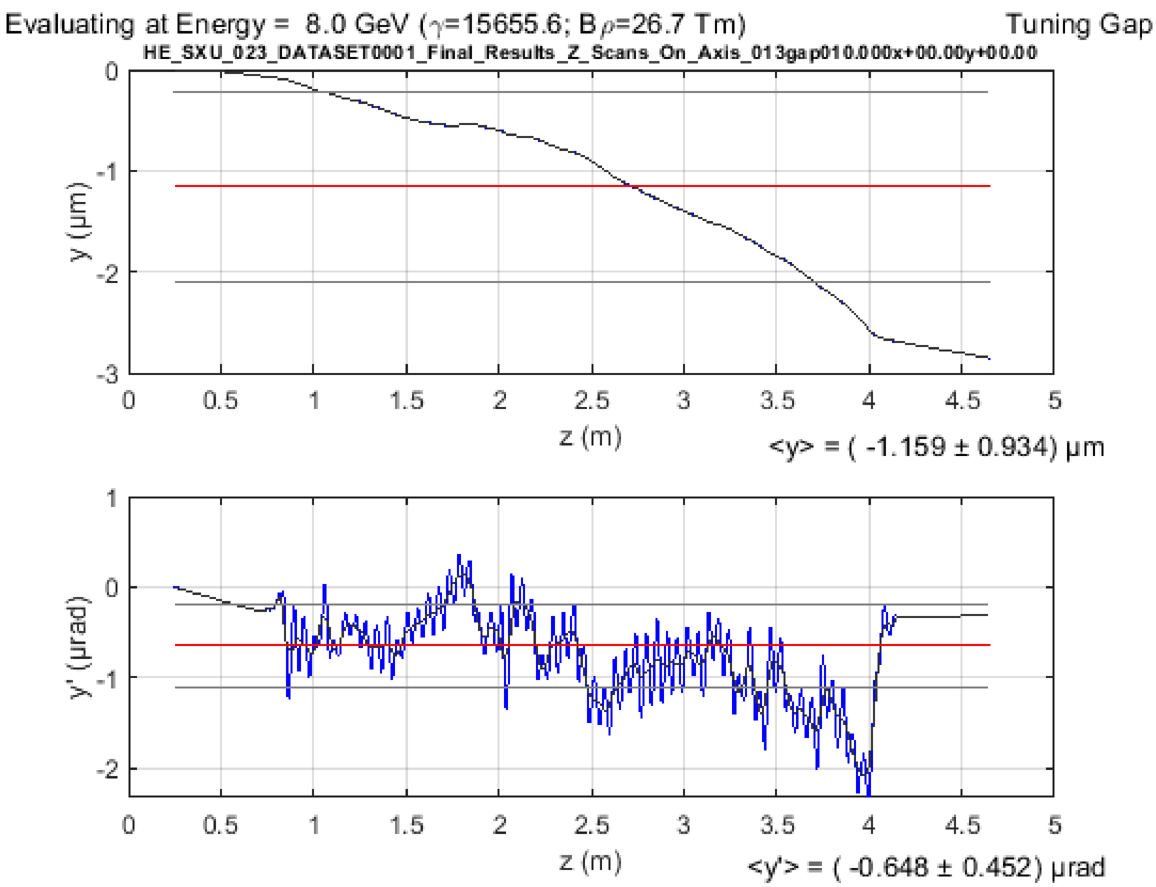
The figures show the x (upper) and y (lower) field components along the undulator tuning axis for the tuning gap. A running undulator-period-average function is plotted in black (not very well visible in the lower figure). The horizontal lines indicate the mean (center red line) and the rms deviations from the mean (two black lines above and below the average) of that undulator-period-average function. The corresponding mean values and standard deviations are also printed on the right hand side underneath each figure. [Documentary Information]

Evaluation of Hall Probe at Tuning Gap: x & x' Plot



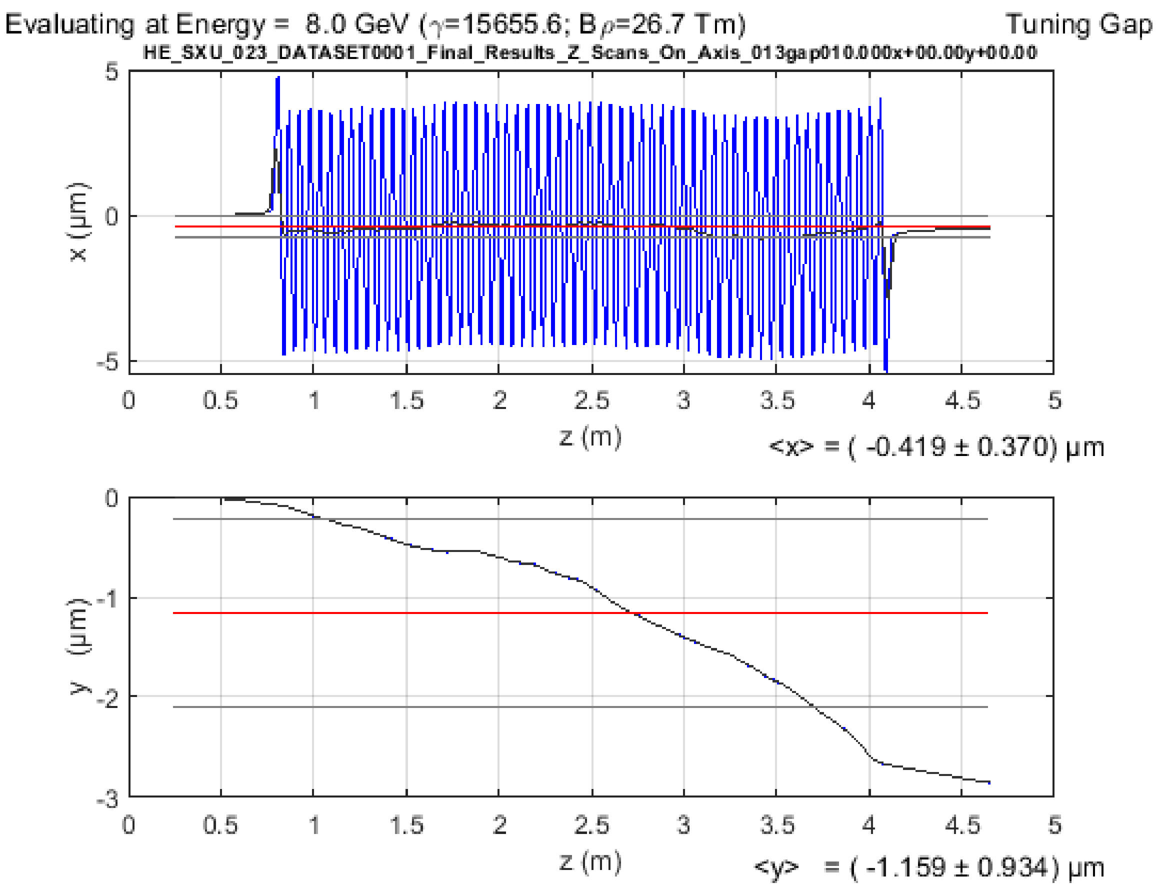
The figures show the x (upper) and x' (lower) electron beam trajectories along the undulator tuning axis for the tuning gap based on the measured magnetic field components and estimated for an electron beam energy of 8.0 GeV. A running undulator-period-average function is plotted in black (difficult to see in the lower figure). The horizontal lines indicate the mean values (center red line) and the standard deviations from the mean (two black lines above and below the average) of that undulator-period-average function. The corresponding mean values and standard deviatons are also printed on the right hand side underneath each figure. [Documentary Information]

Evaluation of Hall Probe Scans at Tuning Gap: y & y' Plot



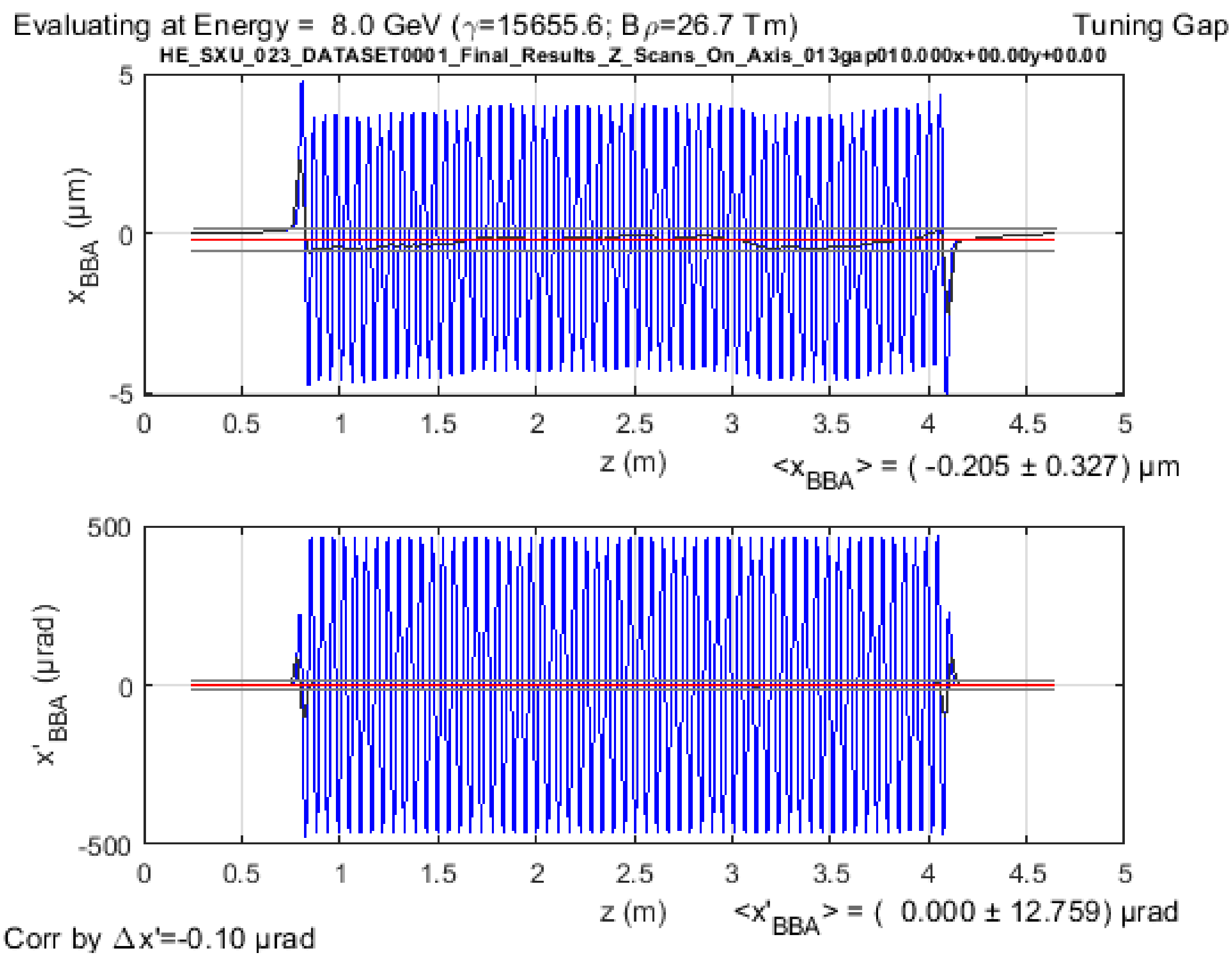
The figures show the y (upper) and y' (lower) electron beam trajectories along the undulator tuning axis for the tuning gap based on the measured magnetic field components and estimated for an electron beam energy of 8.0 GeV. A running undulator-period-average function is plotted in black (difficult to see). The horizontal lines indicate the mean values (center red line) and the standard deviations from the mean (two black lines above and below the average) of that undulator-period-average function. The corresponding mean values and standard deviations are also printed on the right hand side underneath each figure. [Documentary Information]

Evaluation of Hall Probe Scans at Tuning Gap: x & y Plot



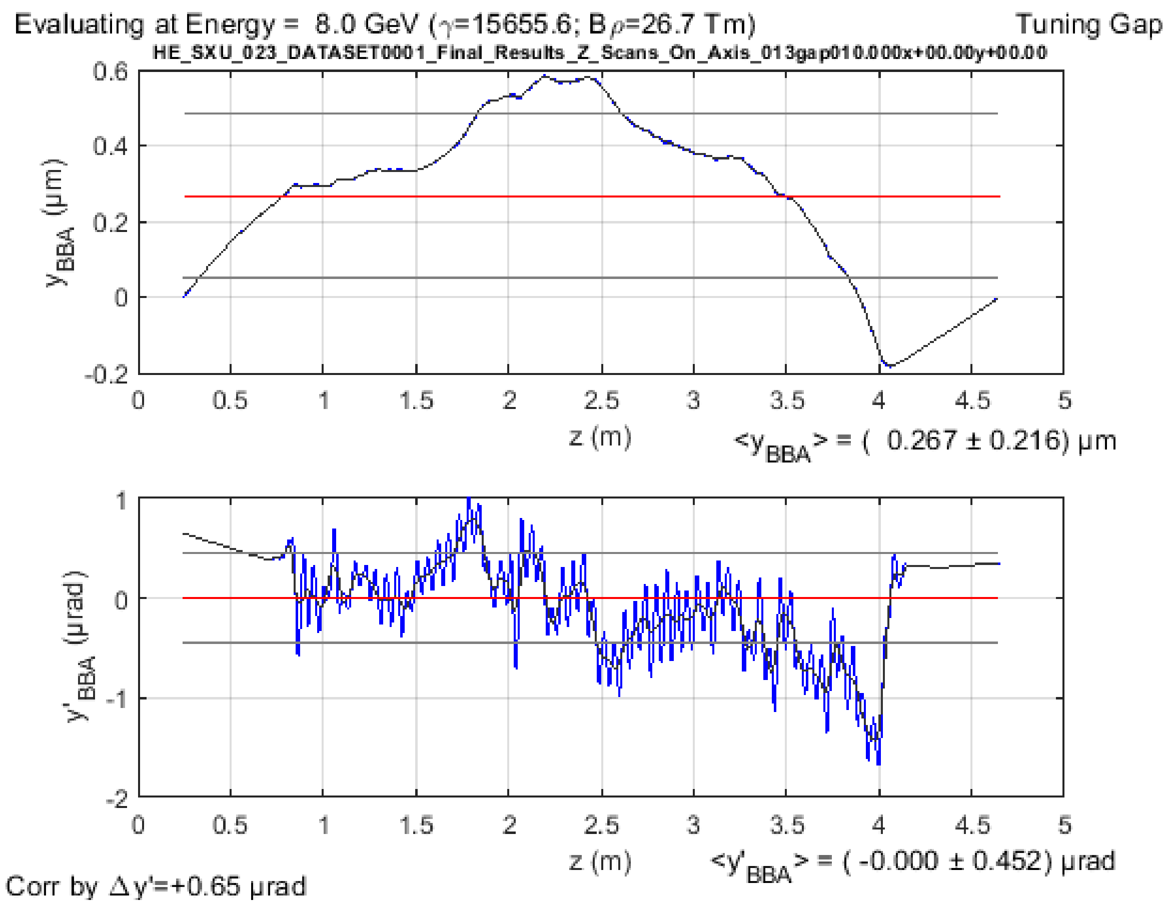
The figures show the x (upper) and y (lower) electron beam trajectories along the undulator tuning axis for the tuning gap based on the measured magnetic field components and estimated for an electron beam energy of 8.0 GeV. A running undulator-period-average function is plotted in black (identical with the trajectory in the lower figure). The horizontal lines indicate the mean values (center red line) and the standard deviations from the mean (two black lines above and below the average) of that undulator-period-average function. The corresponding mean values and standard values are also printed on the right hand side underneath each figure. [Documentary Information]

Evaluation of Hall Probe plus BBA Correction at Tuning Gap: x & x' Plot



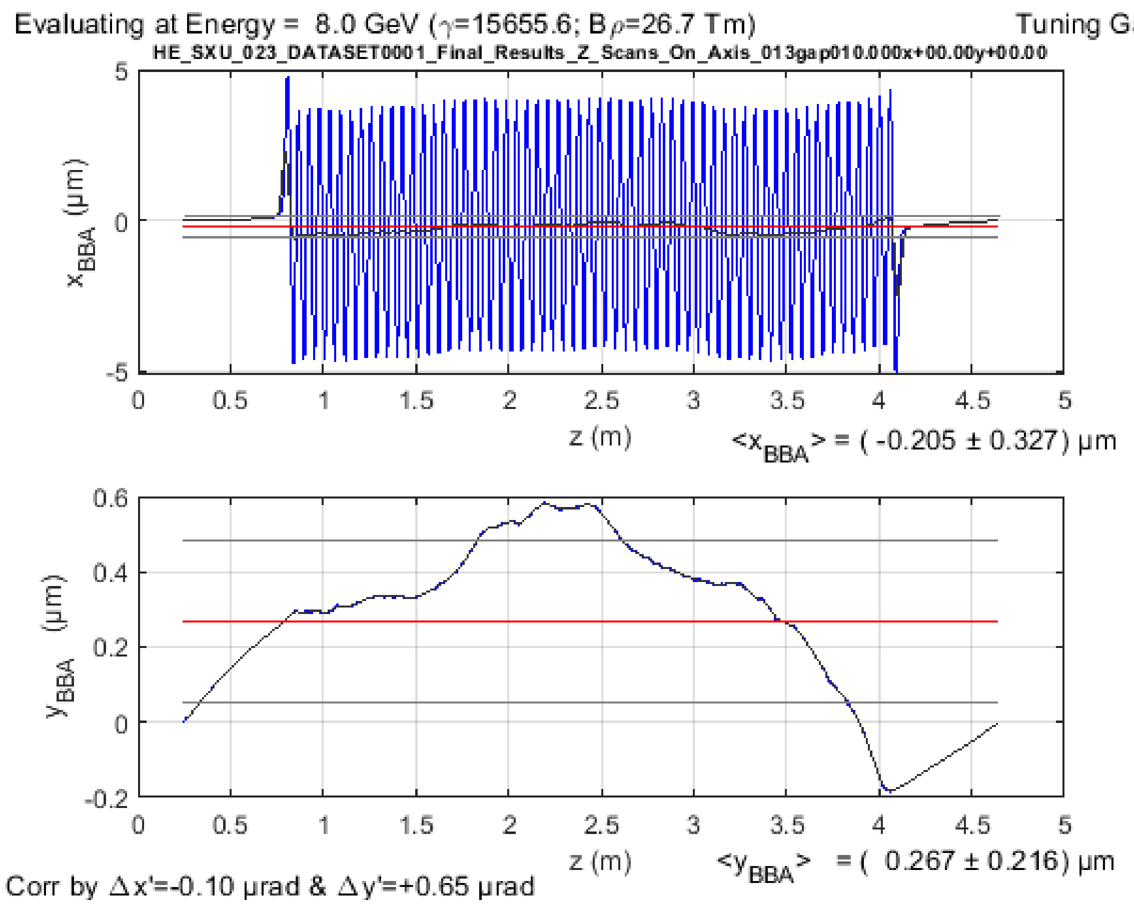
The figures show the x (upper) and x' (lower) electron beam trajectories along the undulator tuning axis for the tuning gap based on the measured magnetic field components after BBA correction (to zero the amplitudes at the cell boundaries) and estimated for an electron beam energy of 8.0 GeV. A running undulator-period-average function is plotted in black (difficult to see in the lower figure). The horizontal lines indicate the mean values (center red line) and the standard deviations from the mean (two black lines above and below the average) of that undulator-period-average function. The corresponding mean values and standard values are also printed on the right hand side underneath each figure. The amount of BBA correction applied is printed underneath the lower left corner of the lower figure. [Documentary Information]

Evaluation of Hall Probe plus BBA Correction at Tuning Gap: y & y' Plot



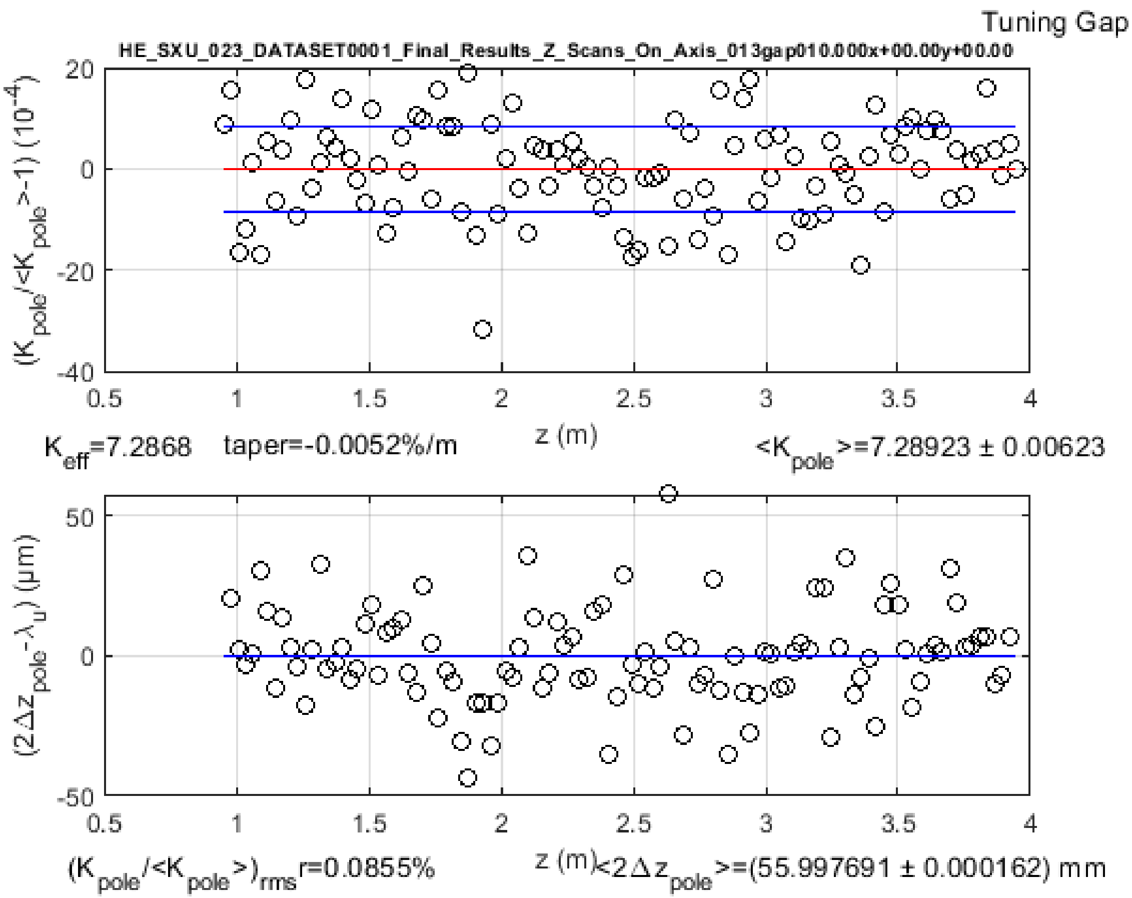
The figures show the y (upper) and y' (lower) electron beam trajectories along the undulator tuning axis for the tuning gap based on the measured magnetic field components after BBA correction (to zero the amplitudes at the cell boundaries) and estimated for an electron beam energy of 8.0 GeV. A running undulator-period-average function is plotted in black (identical with the trajectories). The horizontal lines indicate the mean values (center red line) and the standard deviations from the mean (two black lines above and below the average) of that undulator-period-average function. The corresponding mean values and standard values are also printed on the right hand side underneath each figure. The amount of BBA correction applied is printed underneath the lower left corner of the lower figure. [Documentary Information]

Evaluation of Hall Probe plus BBA Correction at Tuning Gap: x & y Plot



The figures show the x (upper) and y (lower) electron beam trajectories along the undulator tuning axis for the tuning gap based on the measured magnetic field components after BBA correction (to zero the amplitudes at the cell boundaries) and estimated for an electron beam energy of 8.0 GeV. A running undulator-period-average function is plotted in black (identical with the trajectory in the lower figure). The horizontal lines indicate the mean values (center red line) and the standard deviations from the mean (two black lines above and below the average) of that undulator-period-average function. The corresponding mean values and standard values are also printed on the right hand side underneath each figure. The amount of BBA correction applied is printed underneath the lower left corner of the lower figure. [Documentary Information]

Evaluation of Hall Probe at Tuning Gap: K and λ_u Plot



The figures show the per-pole undulator strength K_{pole} (upper) and the deviation of the pole width from the expected value of $\lambda_u/2$ (lower) for the 108 core undulator poles for the tuning gap. The horizontal lines indicate the mean values (center red line) and the standard deviations from the mean (two black lines above and below the average). The corresponding mean values and standard values are also printed on the right hand side underneath each figure. [Documentary Information]

For description of K calculation see next page.

K calculation description for previous page:

The undulator parameter, K_{pole}, in the upper figure, is calculated for each of the core poles based on the scanned vertical field values $B_y(z)$ as well as an interpolation of the upstream, $z_{(0-dn,pole)}$, and downstream, $z_{(0-up,pole)}$, field zero crossing locations using the following formula:

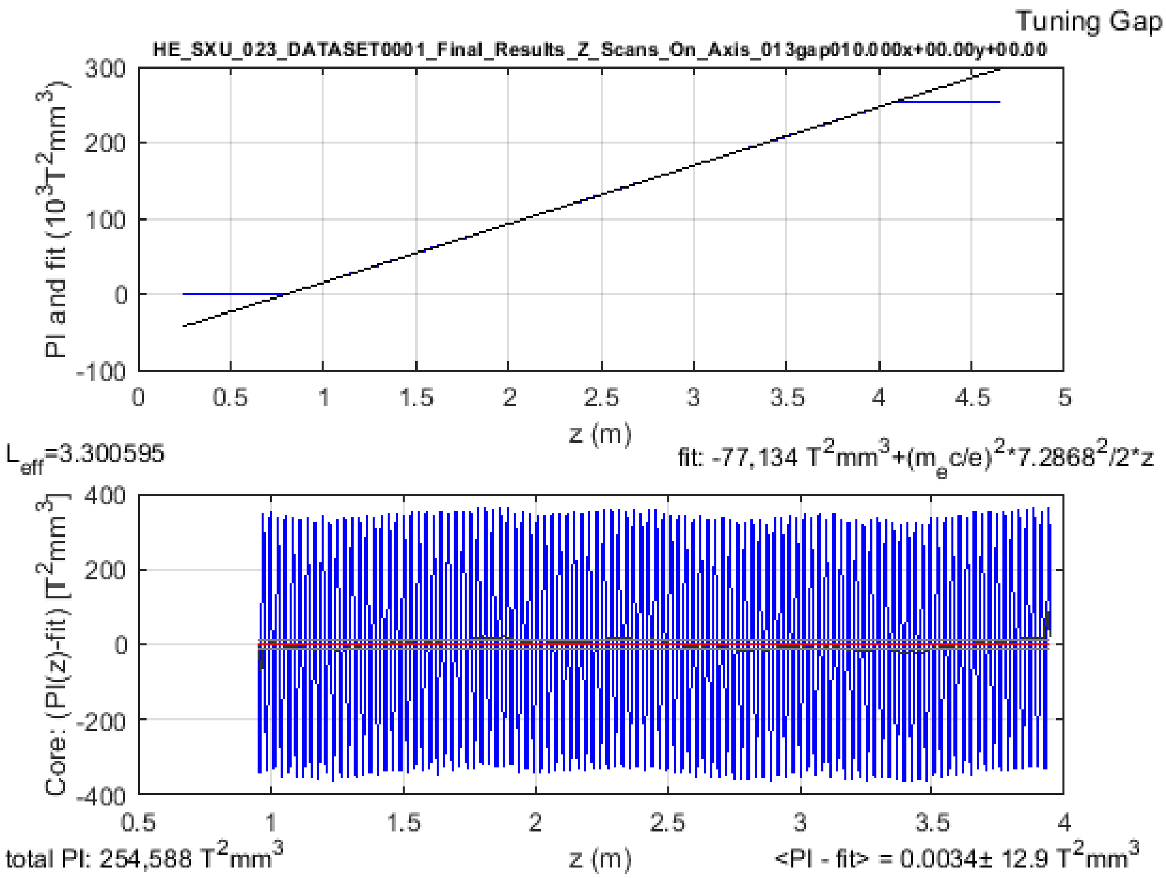
$$K_{pole}(z_{pole}) = \frac{\Delta z_{pole}}{2\pi} \frac{e}{m_e c} \sqrt{\frac{2}{\Delta z_{pole}} \int_{z_{0-up,pole}}^{z_{0-dn,pole}} B_y^2(\hat{z})\, d\hat{z}}$$

The term $\frac{e}{m_e c}$ uses the electron mass, m_e, the speed of light, c, and the electron's electric charge, e. The variable Δz_{pole} stands for

$$\Delta z_{pole} = z_{0-dn,pole} - z_{0-up,pole}$$

$$z_{pole} \approx \frac{1}{2}(z_{0-dn,pole} + z_{0-up,pole})$$

Evaluation of Hall Probe Scans for Tuning Gap: Phase Integral Plot



A description of the figure is given on the next page:

Figure description for previous page:

The upper figure shows the phase integral of an electron calculated from the measured on-axis magnetic field components for the tuning gap:

$$PI\left(z\right)=\int\limits_{0}^{z}BL_{x1}^{2}\left(\hat{z}\right)d\hat{z}+\int\limits_{0}^{z}BL_{y1}^{2}\left(\hat{z}\right)d\hat{z}$$

with

$$BL_{x1,y1}\left(z\right)=\int\limits_{0}^{z}B_{x,y}\left(\hat{z}\right)d\hat{z}-\frac{1}{L}\int\limits_{0}^{L}\left\{\int\limits_{0}^{\tilde{z}}B_{x,y}\left(\hat{z}\right)d\hat{z}\right\}d\tilde{z}.$$

The function

$$\overline{PI}\left(z\right)=\overline{PI}\left(0\right)+z\left(\frac{mc}{e}\right)^{2}\frac{1}{2}K_{\text{eff}}^{2},$$

fitted to the measured phase integral $PI(z)$ (along the undulator core) with fit coefficients $\left(\frac{mc}{e}\right)^{2}\frac{1}{2}K_{\text{eff}}^{2}$ and can be seen as a straight black line in the upper plot. The values of the fit coefficients are printed at the right hand side underneath the upper figure. On the lower left of the upper figure the effective undulator length is printed, which is obtained as the distance over the undulator core, where the blue and black lines in the plot are on top of each other: $L_{\text{eff}}=PI\left(z_{max}\right)/\left(\frac{d\overline{PI}(z)}{dz}\right)$.
The lower figure shows the residuals between the phase integral and the fit function over the core part of the undulator magnet. A running undulator-period-averaged function is plotted in black. The horizontal lines indicate the mean values (center red line) and the standard deviations from the mean (two blue lines above and below the mean) of that undulator-period-averaged function. The corresponding mean values and standard values are also printed on the right hand side underneath the figure. On the lower left of the plot, the total phase integral accumulated along the undulator magnet, is shown, i.e., $PI(z_{max})$, the right-hand side value of the blue line in the upper plot.
The undulator-period averaged phase, $\left\langle\Phi\right\rangle_{\lambda_u}\left(z\right)$ can be calculated from $PI\left(z\right)$ via

$$\left\langle\Phi\right\rangle_{\lambda_u}\left(z\right)=\frac{2\pi}{L_{2\pi}}\left(\frac{e}{mc}\right)^{2}\frac{1}{\lambda_u}\int\limits_{z-\frac{\lambda_u}{2}}^{z+\frac{\lambda_u}{2}}\left(PI\left(\hat{z}\right)-\overline{PI}\left(\hat{z}\right)\right)d\overline{z},\tag{1}$$

integrated over the undulator core.
Here $L_{2\pi}=\lambda_u\left(1+\frac{1}{2}K_{eff}^{2}\right)$ (see next figure) is the free space distance over which a phase slippage of 2π occurs. The phase shake, $\left\langle\Delta\phi\right\rangle_{rms}$, which will be discussed later in this document, is calculated as

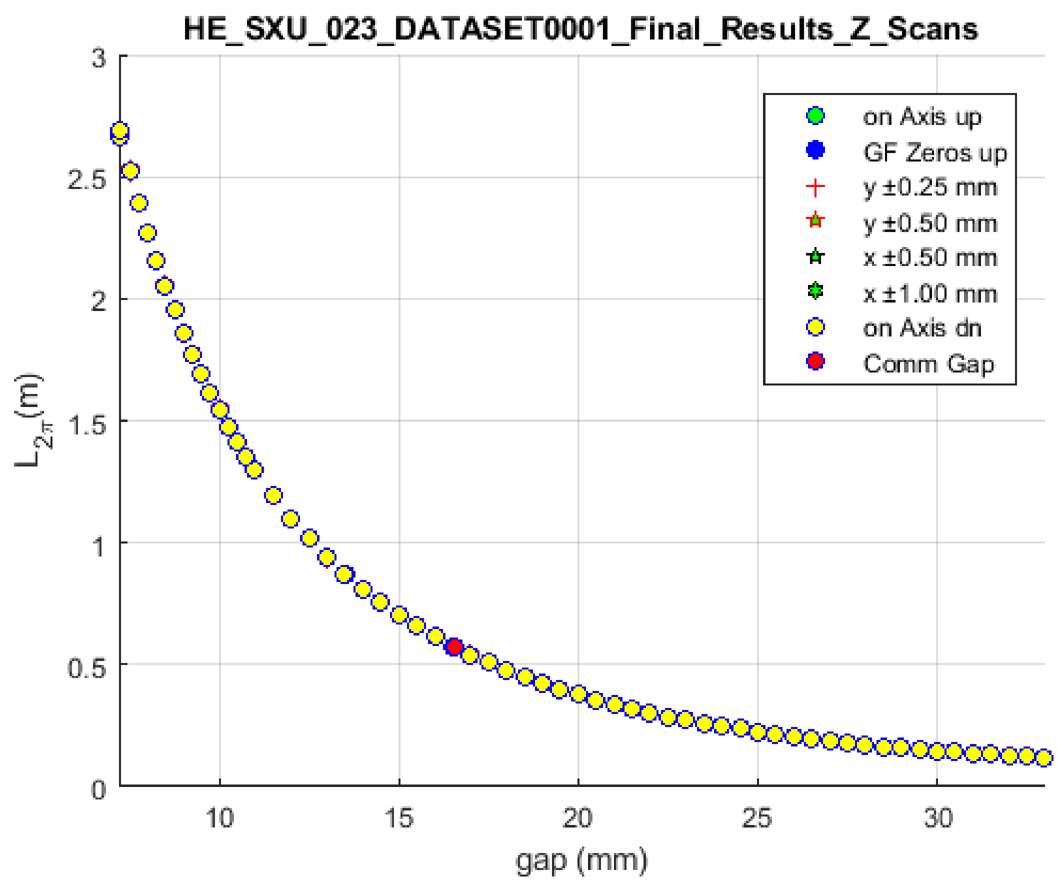
$$\left\langle\Delta\phi\right\rangle_{rms}=\left(\Delta\left\langle\Phi\right\rangle_{\lambda_u}\right)_{rms}=\left(\left\langle\Phi\right\rangle_{\lambda_u}\left(z\right)-\left\langle\left\langle\Phi\right\rangle_{\lambda_u}\left(z\right)\right\rangle\right)_{rms}$$

The cell phase $\phi\left(z\right)$ is calculated over the entire cell length (not just the undulator core)

$$\phi\left(z\right)=\frac{360\text{ degXray}}{L_{2\pi}}\left(z-z_{center}+\left(\frac{e}{mc}\right)^{2}PI\left(z\right)\right).$$

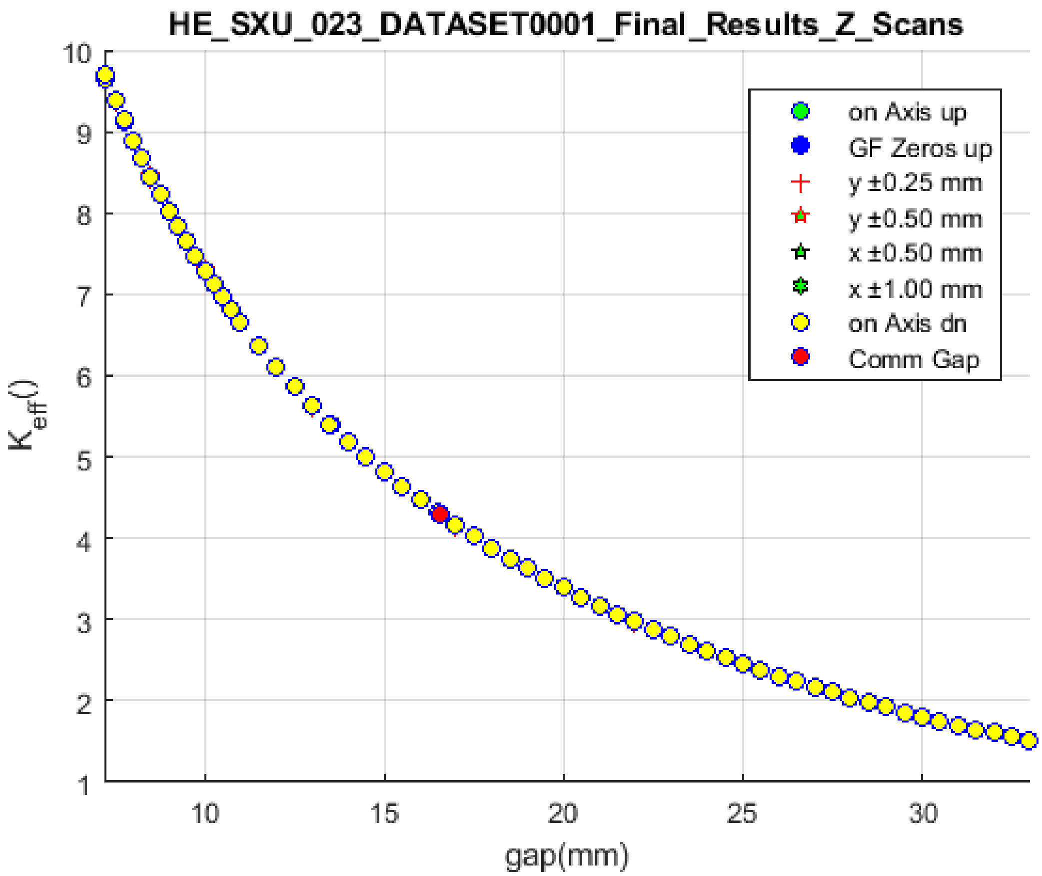
The following figures show the results of the gap dependent analysis.

Evaluation of Hall Scans: $L_{2\pi}$ vs gap



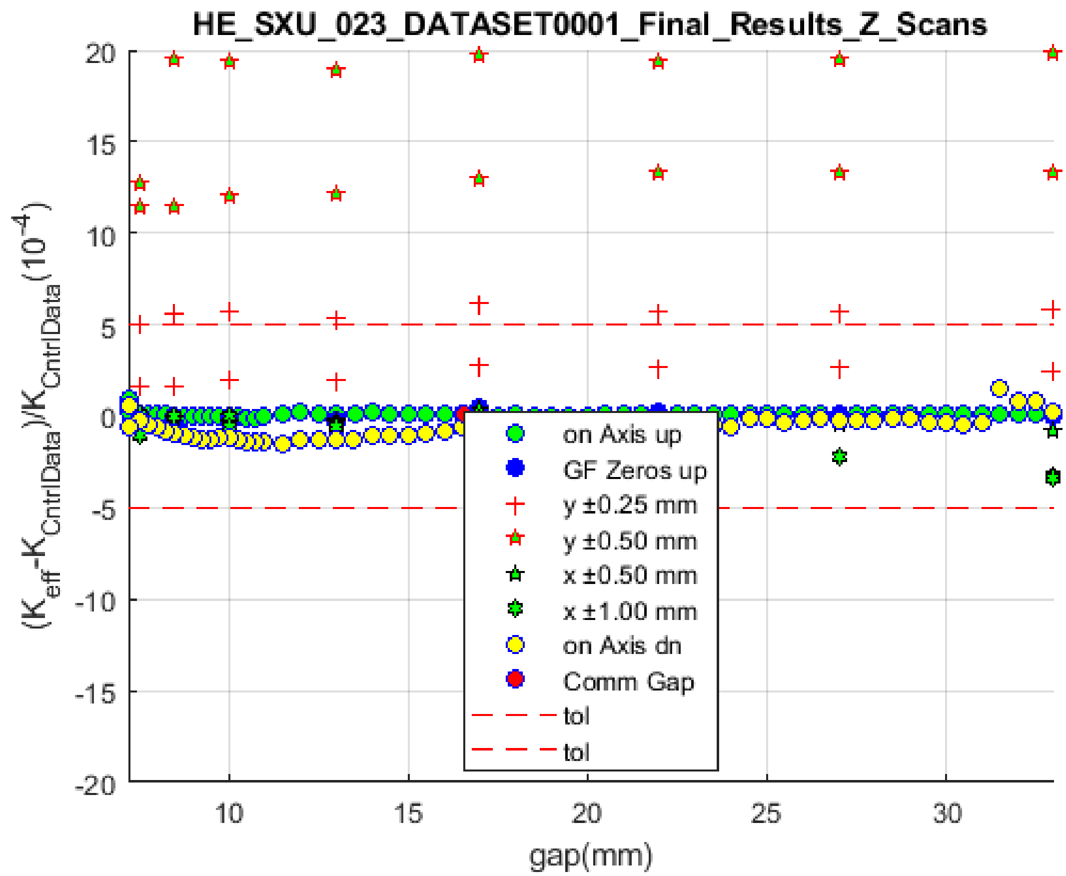
The figure shows the free space distance over which a 2π slippage occurs between the radiation field and the electron bunch (see explanation above) as a function of undulator gap over the operational gap range. Note: the free space travel distance required to accumulate 2π slippage gets shorter towards larger gap values, which correspond to shorter undulator wavelengths. [Documentary Information]

Evaluation of Hall Scans: K_{eff} vs gap



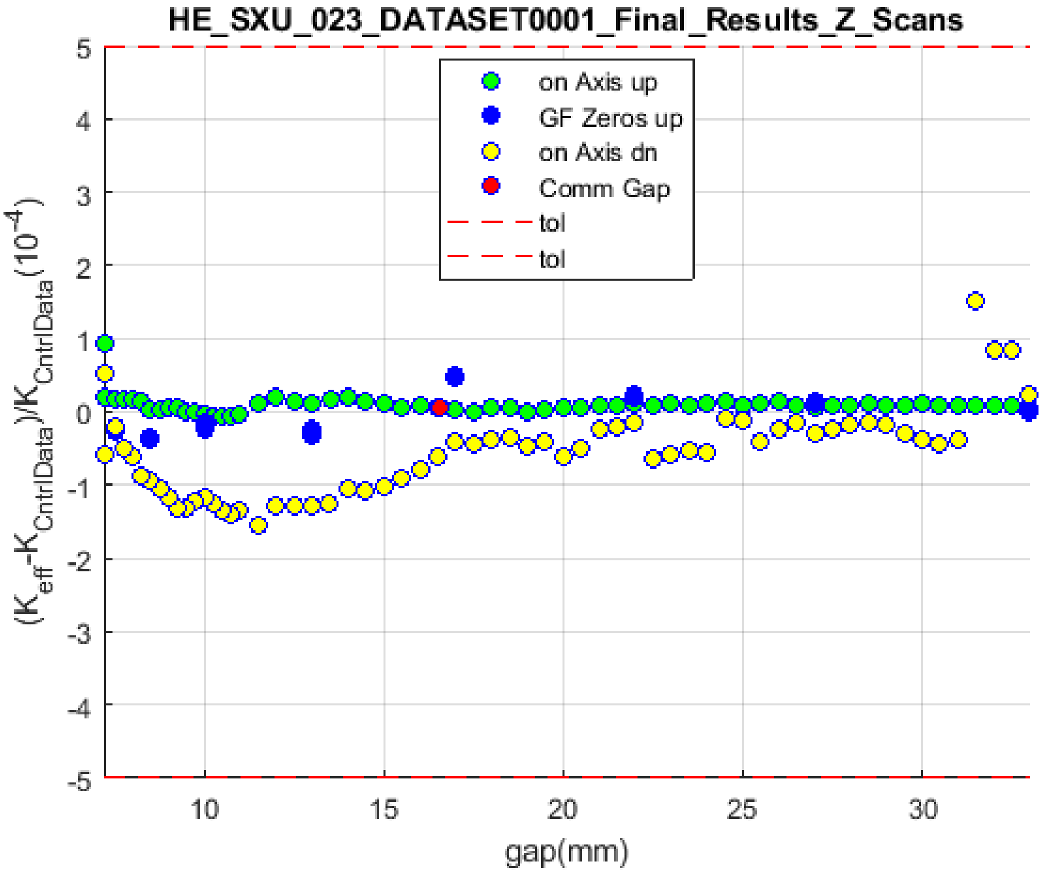
The figure shows undulator strength K_{eff} as a function of gap over the 7.2 mm—33 mm operational range. The legend shows a number of different cases that will be explained later in this document, because their effect cannot be observed in this full scale plot. Note: The gap values are derived from the readings of the two gap encoders installed on the SXU. In that sense these are nominal gap numbers that will be close but not identical to each of the individual pole separations measured across the undulator gap.
The continuous conversion between the two axes (i.e. K_{eff}(gap) and gap(K_{eff})) will be done during operations based on the list of reference data points stored in file `sxu_023_k_vs_gap_spline.dat` in the Controls Data folder on the V: drive (see final section of this document for file information). From that list K_{eff}(gap) and gap(K_{eff}) can be calculated via cubic spline fits or equivalent. [Documentary Information]

Evaluation of Hall Scans: $K_{\text{eff}} - K_{\text{control}}$ vs gap



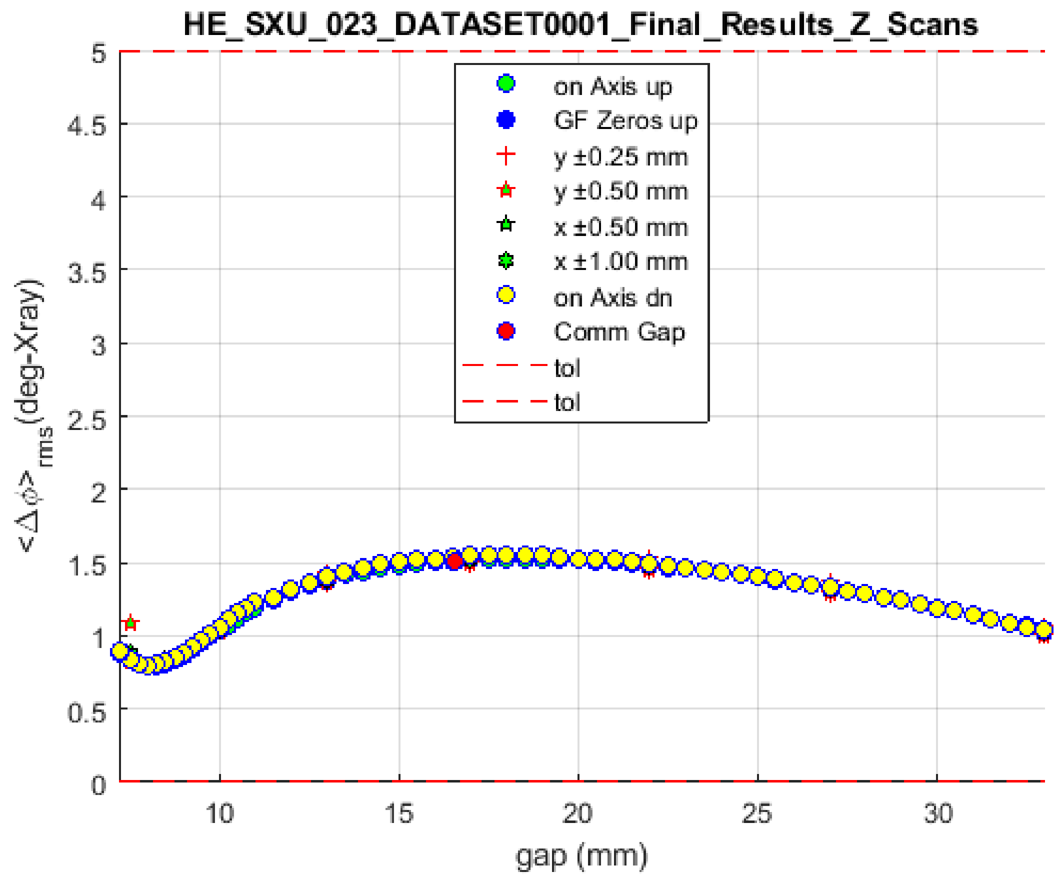
The figure shows the relative difference between the measured undulator strength Keff and a cubic spline fit to the list of reference data points stored in file `sxu_023_k_vs_gap_spline.dat` in the Controls Data folder on the V: drive as a function of gap over the 7.2 mm—33 mm operational range.
The legend explains the different cases that are shown in the plot: The green filled circles are data acquired on axis as the gap was changed from close to open. The yellow filled circles are data acquired on axis as the gap was changed from open to close. The horizontal red dashed lines show the tolerance limits. Note: The undulator K_{eff} value shows a hysteresis, i.e., for a given gap, the value depends on the direction of gap motion to reach that gap. While this is not a desirable feature, its effect stays within the given tolerance and will be acceptable. The other symbols shown indicate off-axis measurements that are added for interest only. The tolerance limits apply for on-axis readings, only.

Evaluation of Hall Scans: $(K_{\mathrm{eff}} - K_{\mathrm{CntrlData}})\,/K_{\mathrm{CntrlData}}$ vs gap



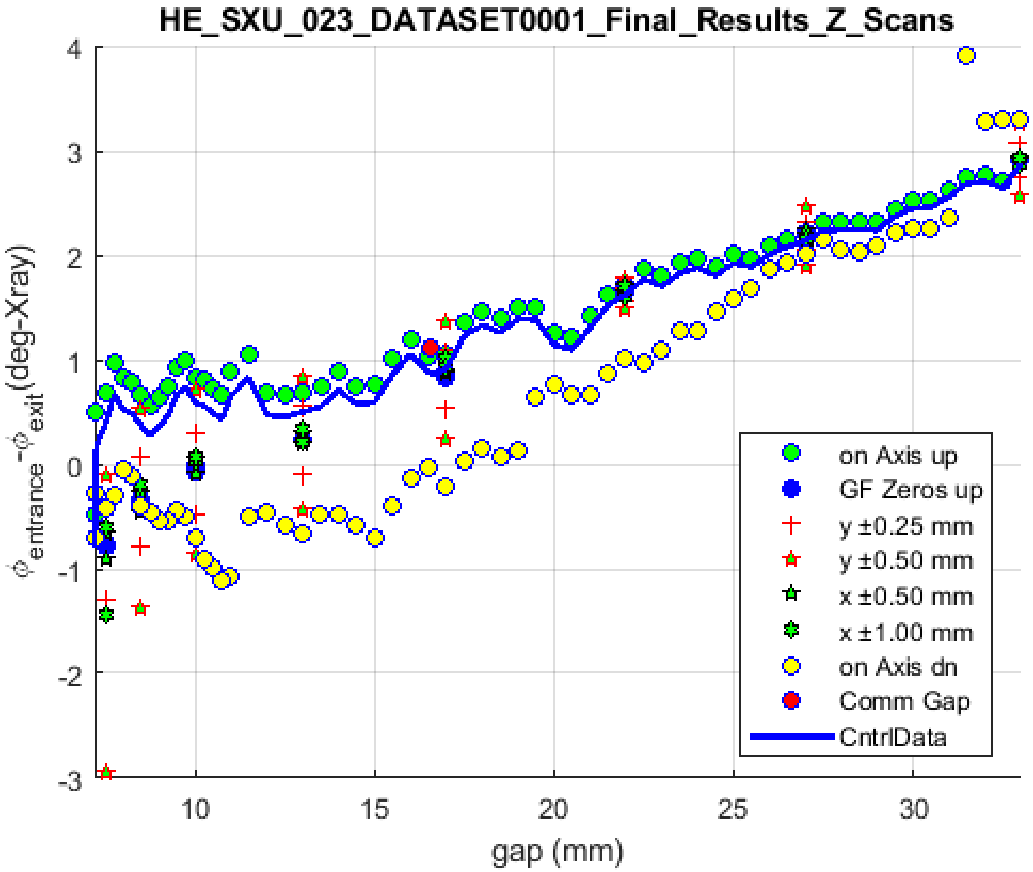
The figure shows some of the data shown in the previous figure but with a larger vertical scale that just captures the tolerance range. The off-axis measurements are not shown.

Evaluation of Hall Scans: Phase Shake vs gap



The figure shows the phase shake, $\langle\Delta\phi\rangle_{rms}$, (see Eq. 1 above on page 15) as a function of operational gap. The vertical axis extends over the entire tolerance range. The values show a slight hysteresis (show explanation above) but are well within tolerance.

Evaluation of Hall Probe: Entrance to Exit Phase Error Balance vs. gap



The figure shows a (negligible) imbalance of the entrance (cell boundary start to undulator core) to the exit (undulator core to cell boundary end) phase slippage for the undulator. In addition to the signals described above, the blue curve is a spline fit to the difference of the data in files

"..._phase_match_enter_vs_gap_spline.dat"
"..._phase_match_exit_vs_gap_spline.dat".

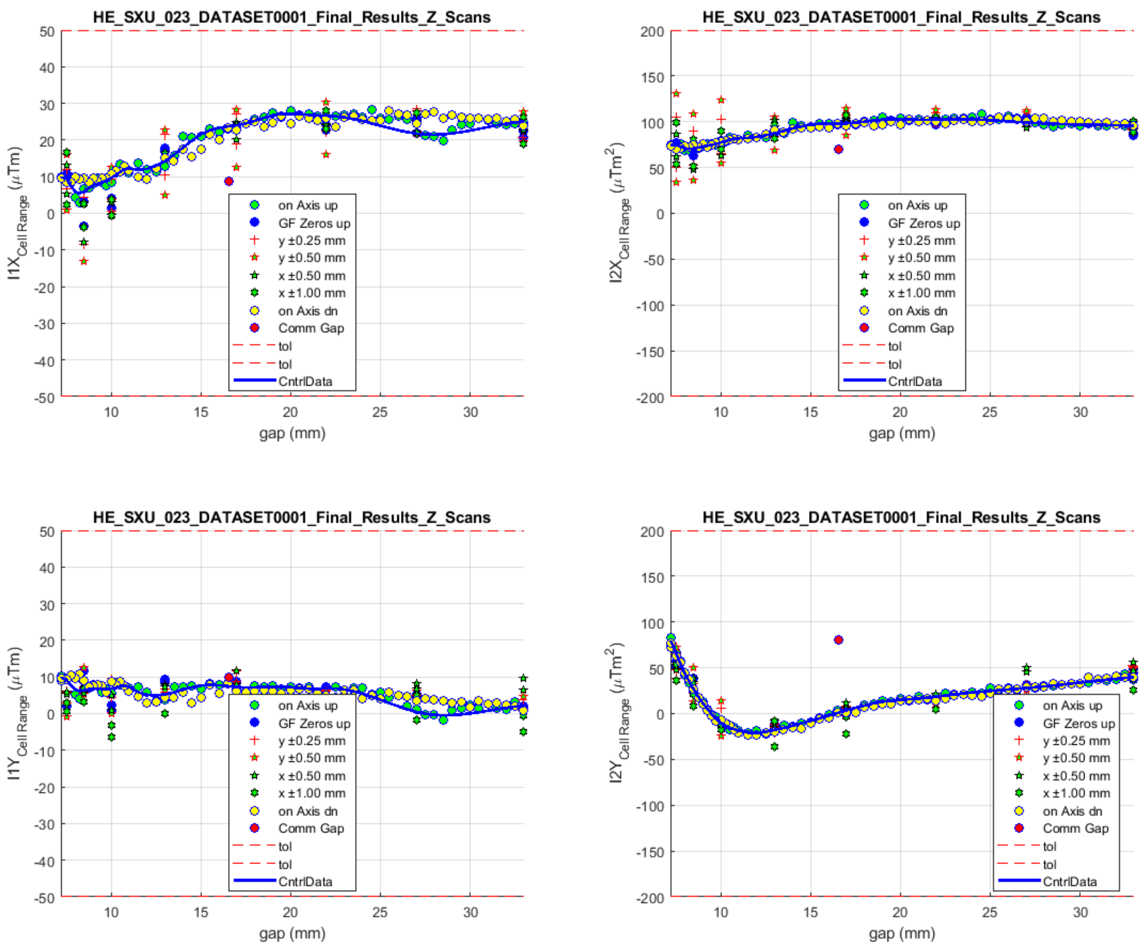
The small change in phase difference between opening and closing measurements shows the effect of gap hysteresis. The explanation for the legend items can be found on previous pages above. The entrance and exit phase slippage is calculated as

$$\phi_{\text{entrance}} = -\phi\left(z_{\text{Cell-Start}}\right) + \frac{1}{n+1}\sum_{j=1}^{n+1}\left(\phi\left(z_{(B0,j)}\right) - \pi\left(j-1\right)\right). \tag{2}$$

$$\phi_{\text{exit}} = -\phi\left(z_{\text{Cell-End}}\right) - \frac{1}{n+1}\sum_{j=1}^{n+1}\left(\phi\left(z_{(B0,j)}\right) + \pi\left(n+1-j\right)\right). \tag{3}$$

Here, $z_{(B0,j)}$ is the z location of the zero crossing of $B_y(z)$ in front of the j^{th} core B_y peak. $z_{(B0,(n+1))}$ is the z location of the field zero of $B_y(z)$ after the last core B_y peak.

Evaluation of Hall Probe: Field Integrals vs. gap

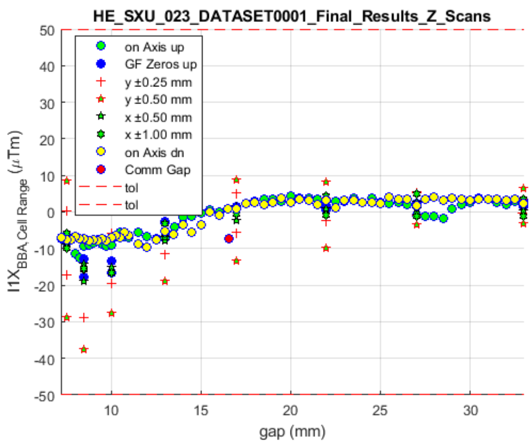


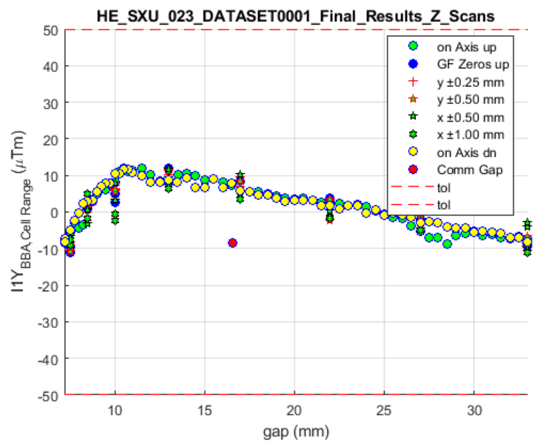
The figures show the field integrals (I1X, I2X, I1Y, I2Y) as functions of the operational gap. The proximity of the green and yellow circles shows that the field integrals are not sensitive to the hysteresis in K as seen on a previous page. The blue curves are spline fits to the data in files

"...i1xvsgap_spline.dat",
"...i2xvsgap_spline.dat",
"...i1yvsgap_spline.dat",
"...i2yvsgap_spline.dat",

and demonstrate how the controls representations of the field integrals relates to the actual measurements (see final section of this document for file information).

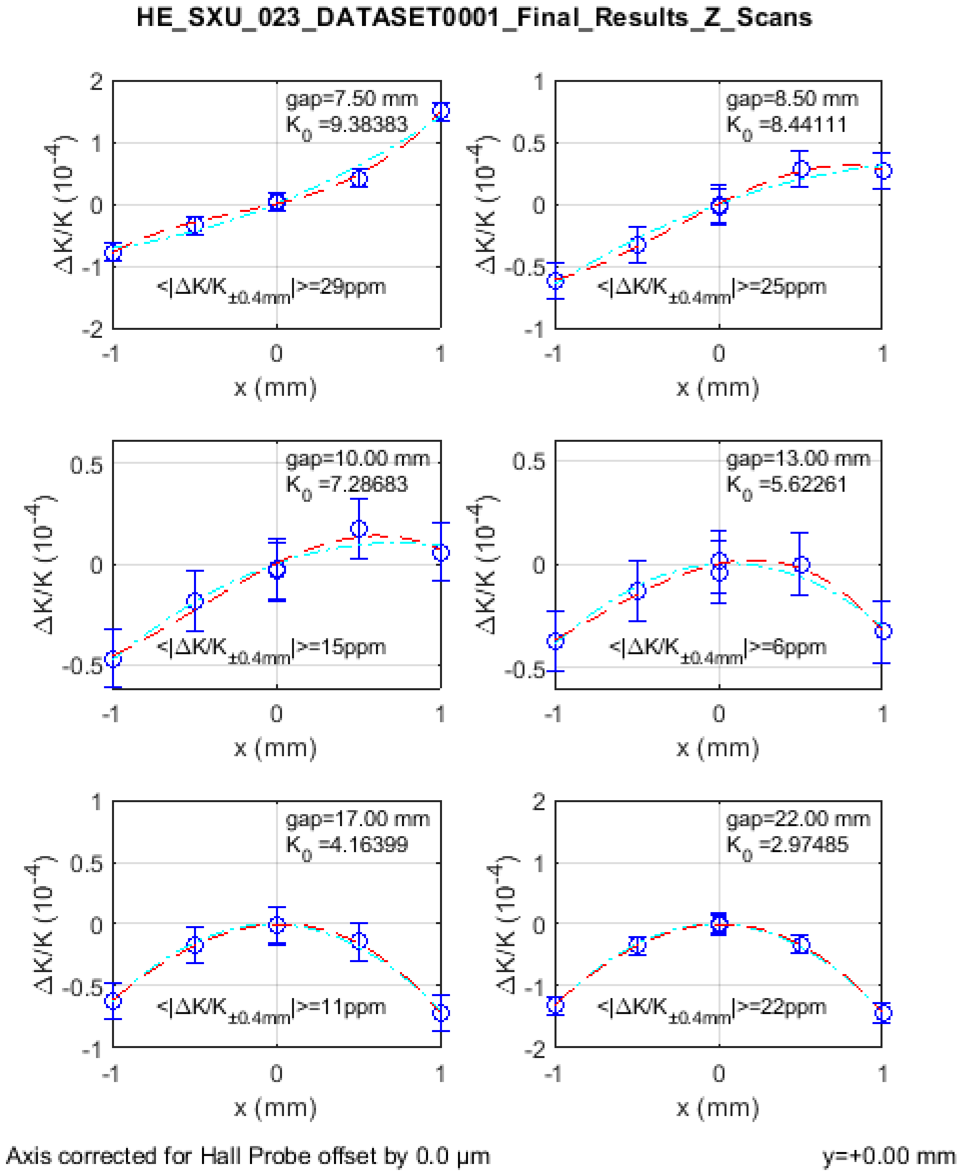
Evaluation of Hall Probe: BBA Field Integrals





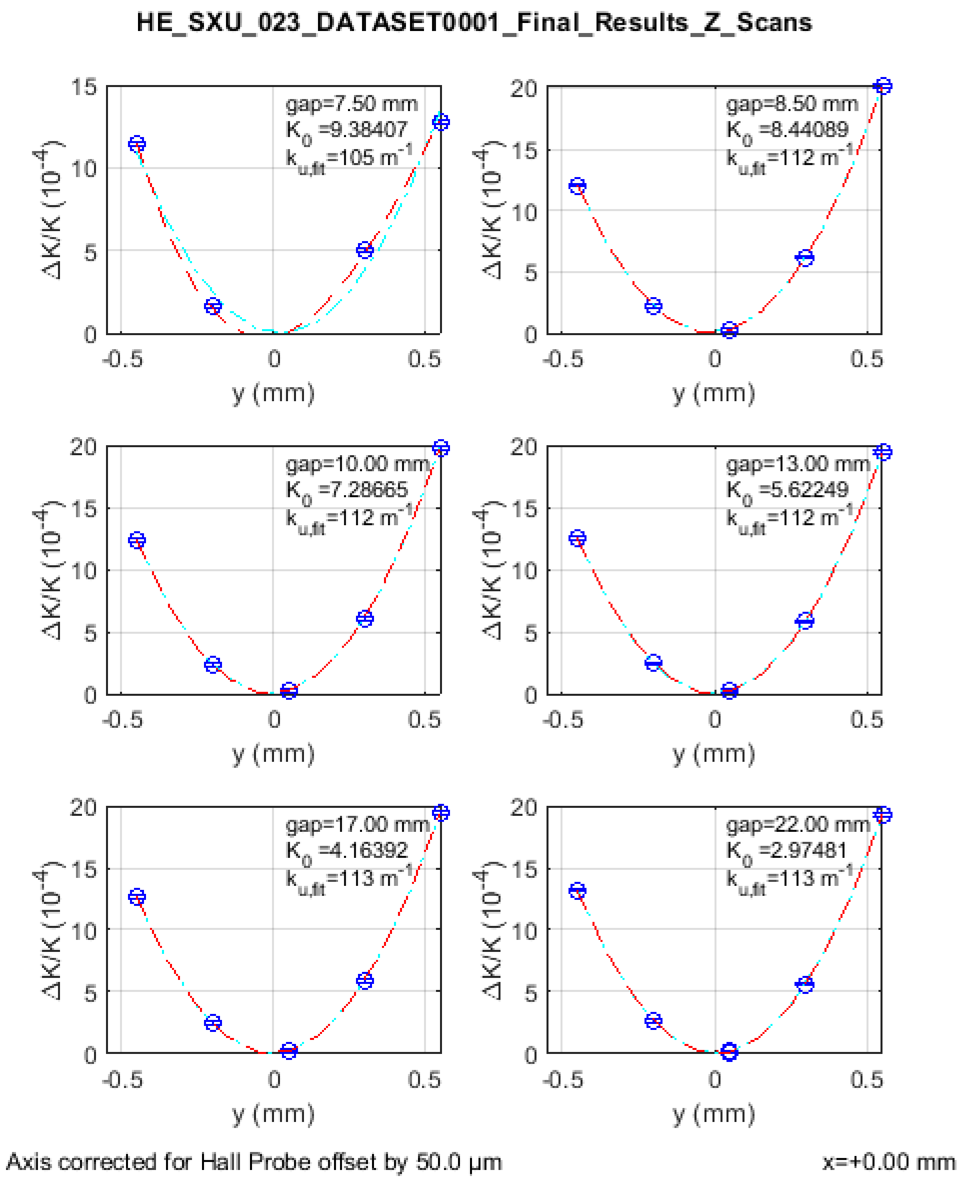
The figure shows the first integrals after a BBA equivalent correction was applied. The values stay within tolerance over the operational range.

Evaluation of Hall Scans: K vs. x dependence



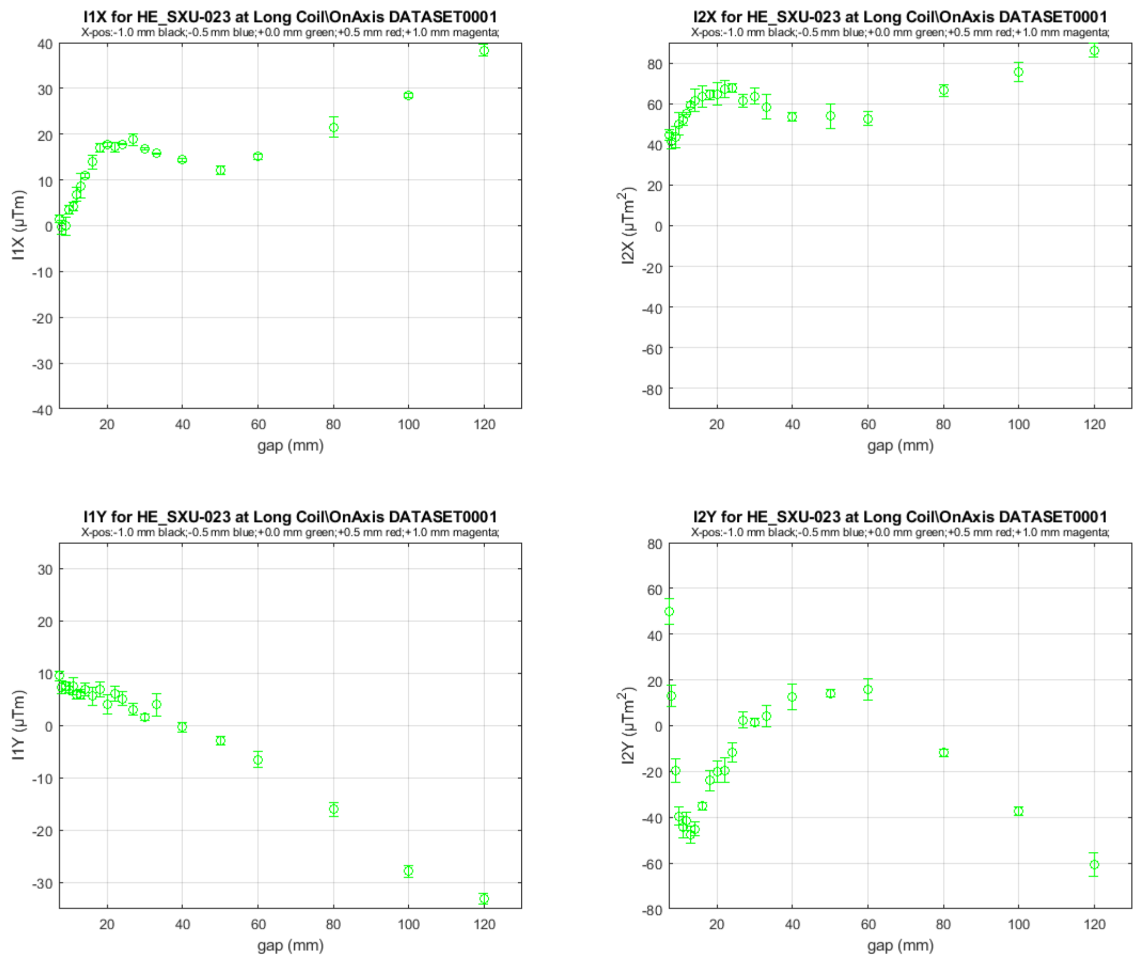
The figure shows the deviation of the relative undulator strength, K, from the off-axis value, K_0, as function of x at a number of operational gaps. The dash—dot lines are polynomial fits to the data (cyan: 2^{nd} order, red: 3^{rd} order). The average deviation at $z = 0.4$ mm is well below the tolerance of 160 ppm in all cases.

Evaluation of Hall Scans: K vs. y dependence



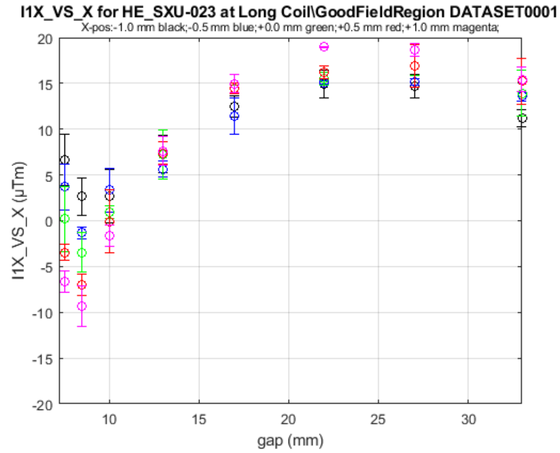
The figure shows the deviation of the relative undulator strength, K, from the off-axis value, K_0, as function of y at a number of operational gaps. The dash—dot lines are polynomial fits to the data (cyan: 2^{nd} order, red: 3^{rd} order). The deviations follow closely the expected functional form $(\cosh(k_u y) - 1)$. The value of $k_{\mathrm{u,fit}}$, calculated from the fit parameters, is recorded in the upper right hand corner of each figure. These values are quite close to the expected value of 112.204 m^{-1}.

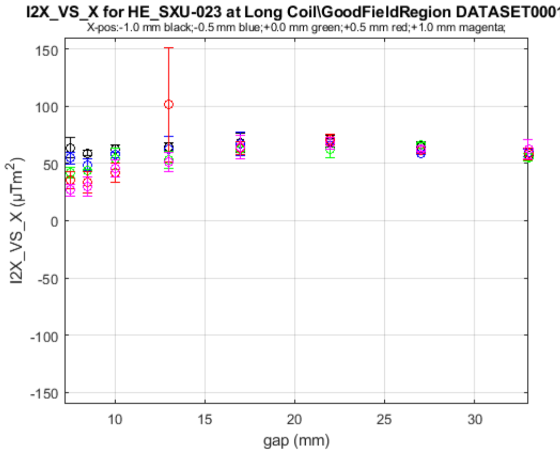
Long Coil Measurement of the On-Axis Field Integrals

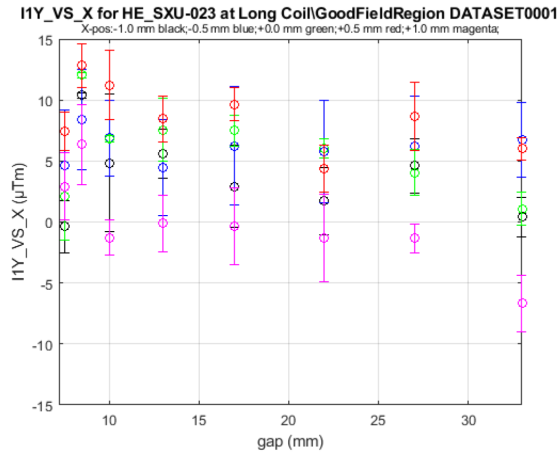


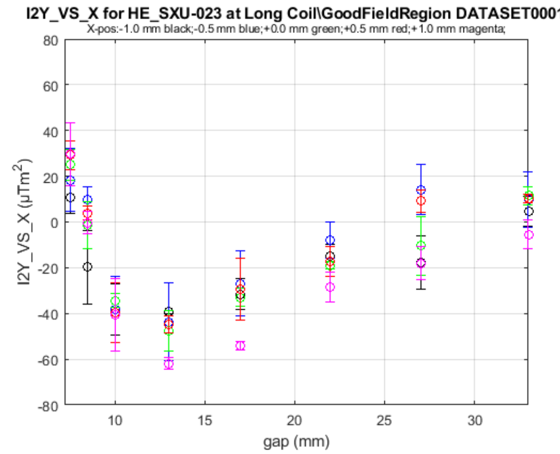
The figure shows the field integrals obtained from long coil measurements on-axis. The vertical axes extend over the tolerance range. All integrals are in tolerance.

Long Coil Measurement of the Horizontally Off-Axis Field Integrals



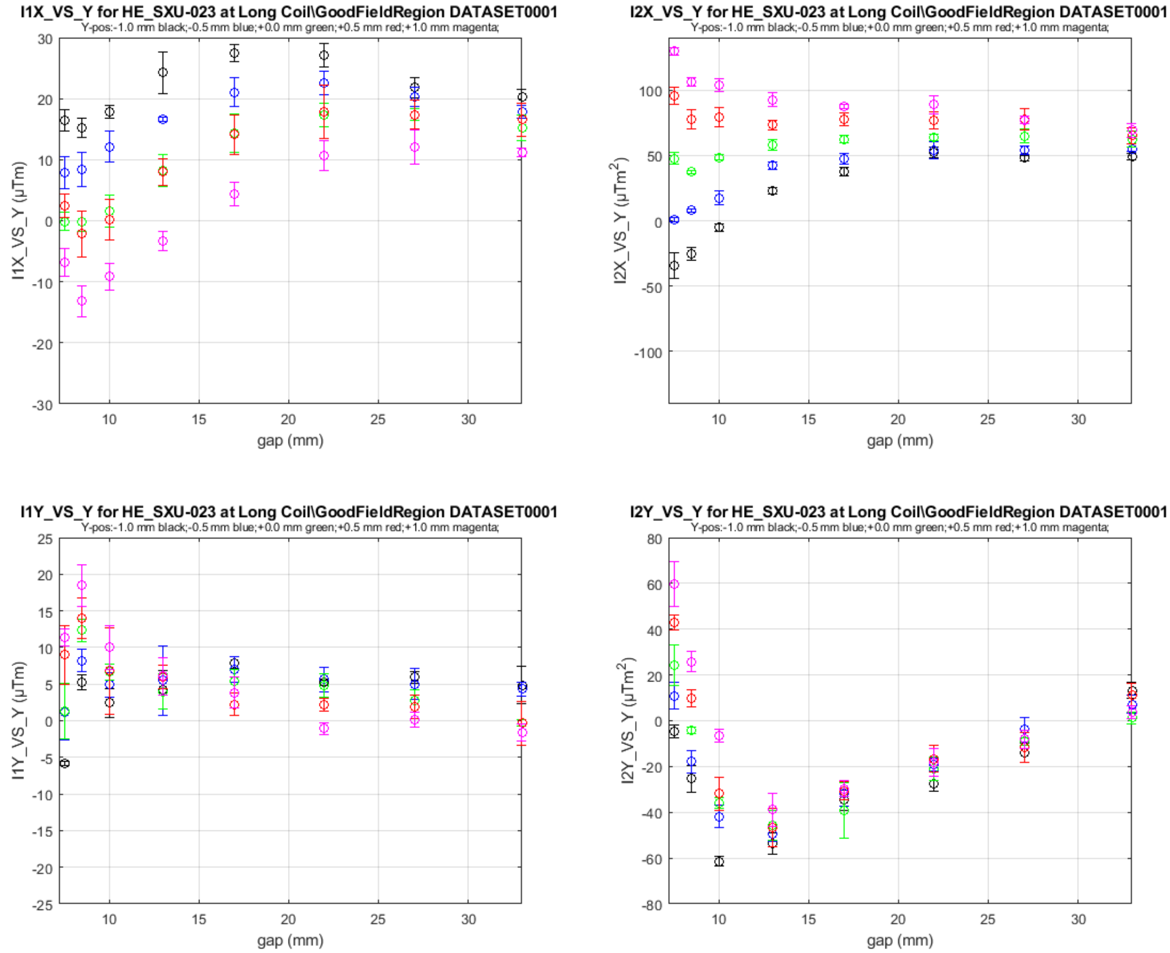






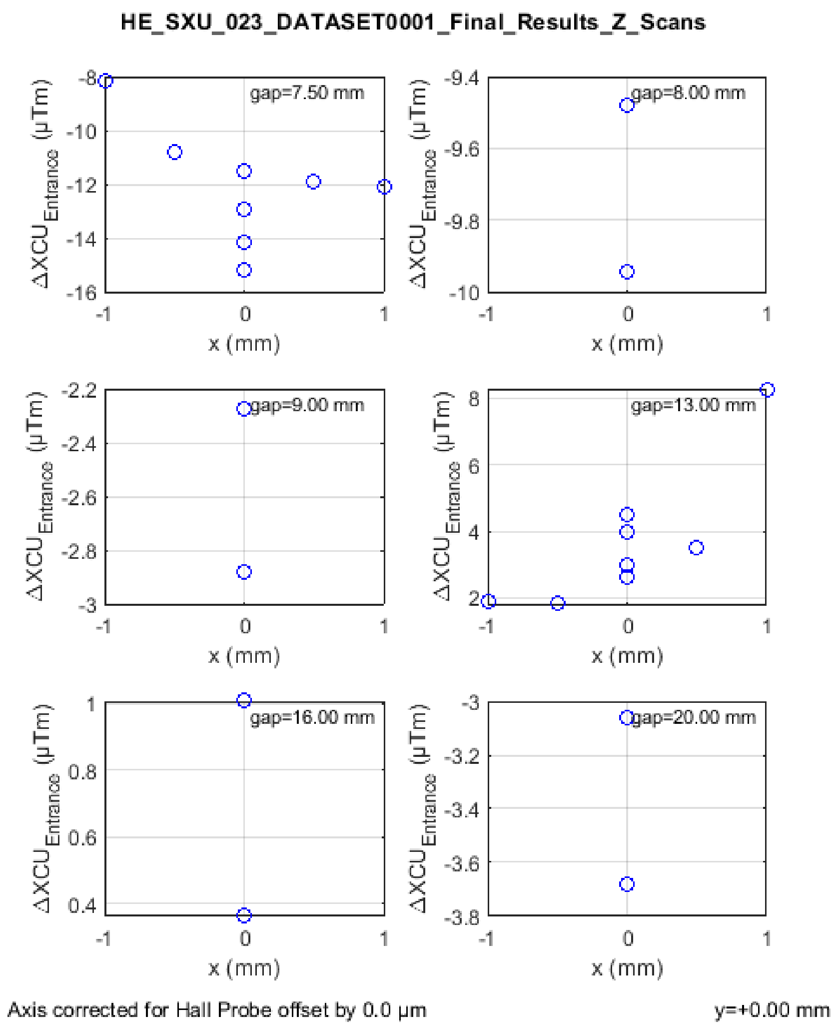
The figure shows the integrals obtained from long coil measurements off axis in the vertical plane using colors to indicate offset distance (black: -1.0 mm, blue: -0.5 mm, green: on-axis; red: +0.5 mm, magenta: +1.0 mm). The vertical axes extend of the tolerance range. All integrals are in tolerance.

Long Coil Measurement of the Vertically Off-Axis Field Integrals



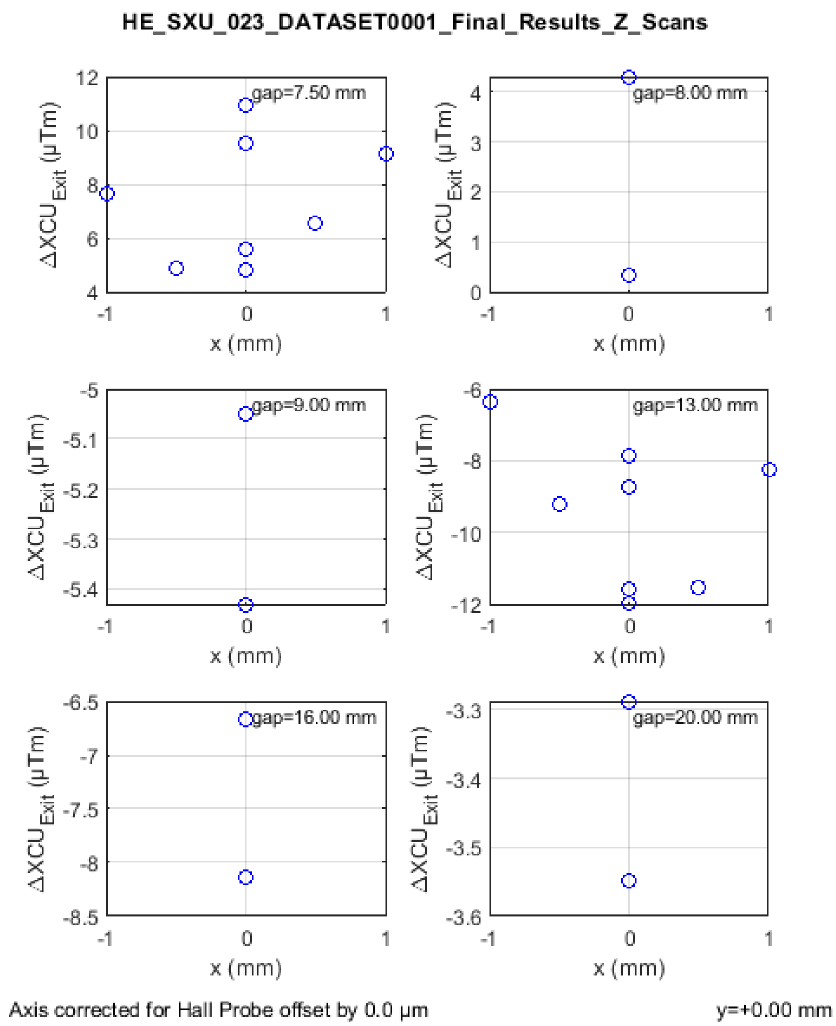
The figure shows the field integrals obtained from long coil measurements off axis in the horizontal plane using colors to indicate offset distance (black: -1.0 mm, blue: -0.5 mm, green: on-axis; red: +0.5 mm, magenta: +1.0 mm). The vertical axes extend over the tolerance range. All integrals are in tolerance.

Estimated Upstream Horizontal Corrector Strength Requirement vs. x



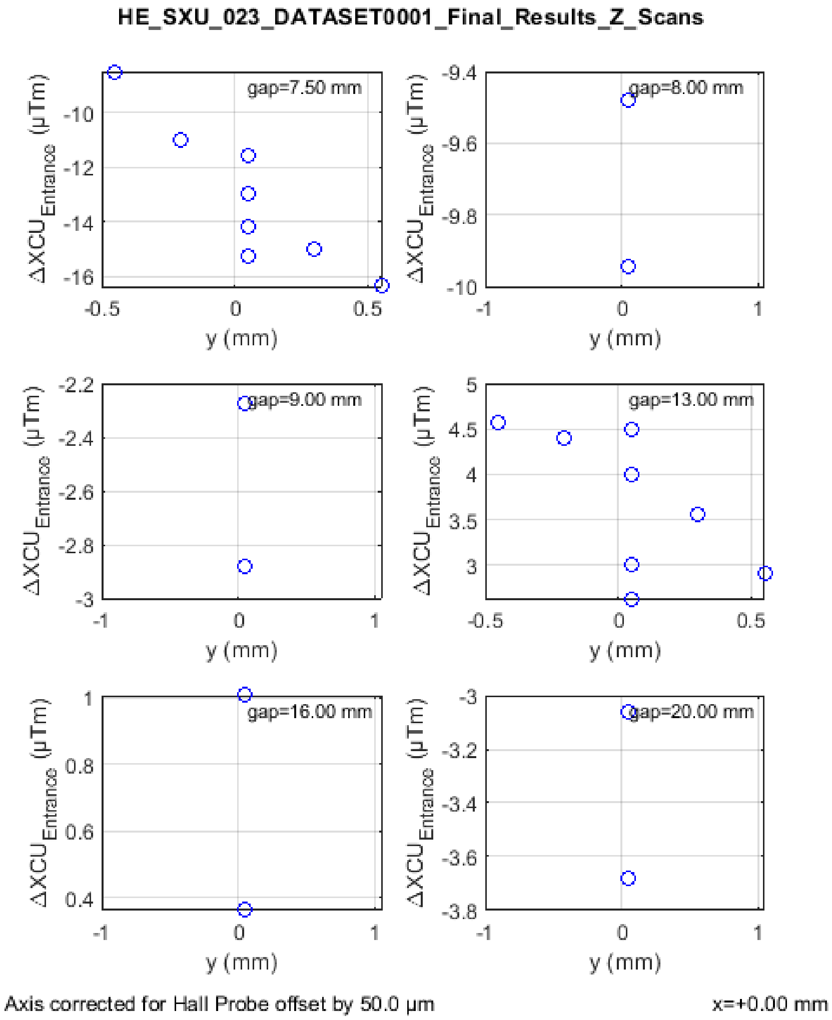
The figure shows the required strength of the upstream horizontal corrector to remove the second vertical undulator field integral at the downstream BPM for a number of operational undulator gaps. The analysis was done at a number of off-axis locations in the x-z plane. All values are small and well below the maximum correction capabilities of greater than 550 μTm of the actual correctors.

Estimated Downstream Horizontal Corrector Strength Requirement vs. x



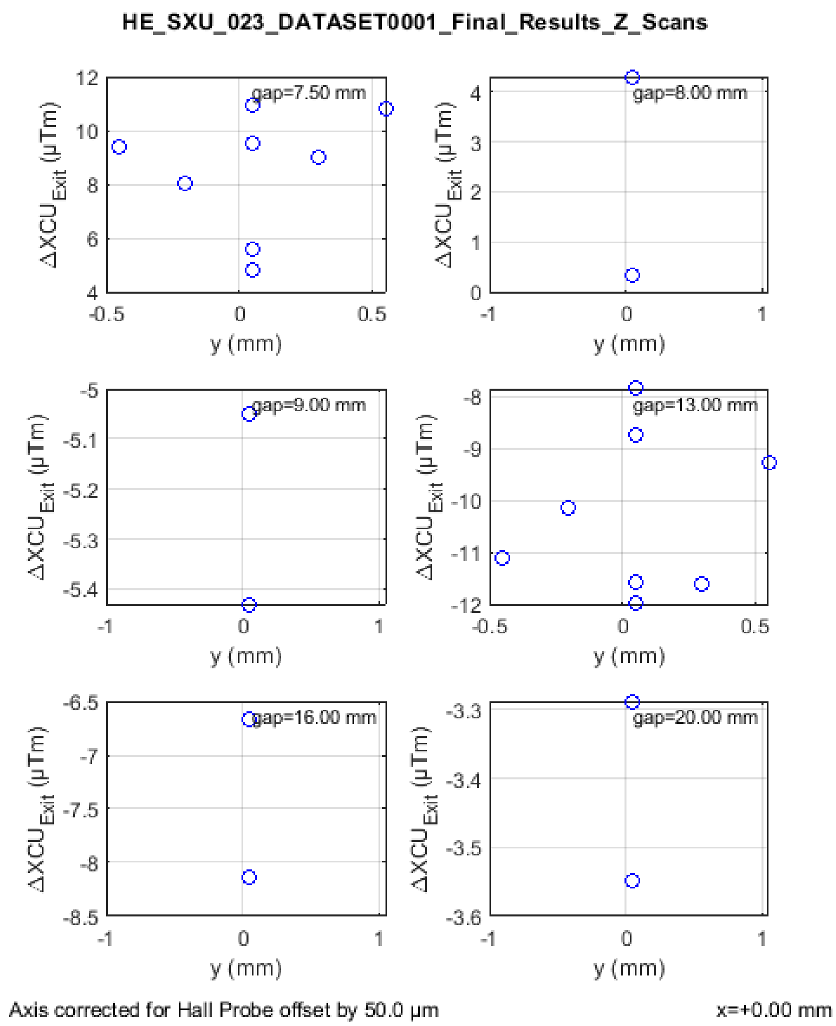
The figure shows the required strength of the downstream horizontal corrector to remove the first vertical undulator field integral and upstream corrector field integral at the downstream BPM for a number of operational undulator gaps. The analysis was done at a number of off-axis locations in the x-z plane. All values are small and well below the maximum correction capabilities of greater than 550 μTm of the actual correctors.

Estimated Upstream Horizontal Corrector Strength Requirement vs. y



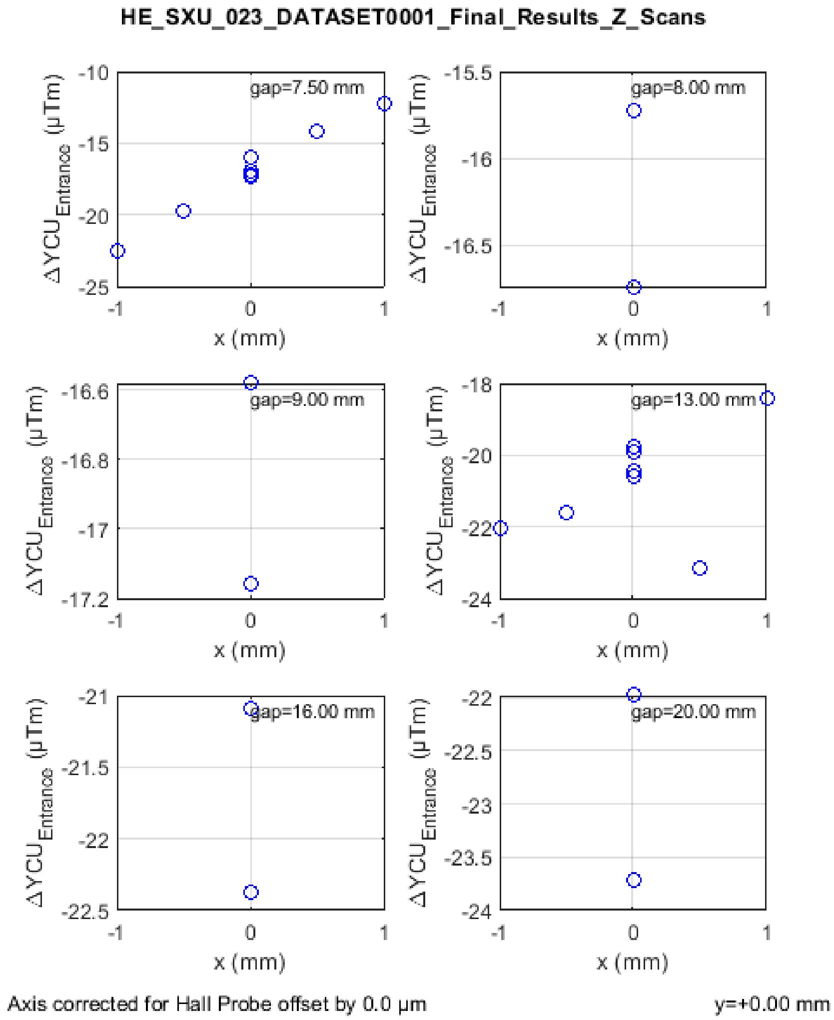
The figure shows the required strength of the upstream horizontal corrector to remove the second vertical undulator field integrals at the downstream BPM for a number of operational undulator gaps. The analysis was done at a number of off-axis locations in the y-z plane. All values are small and well below the maximum correction capabilities of greater than 550 μTm of the actual correctors.

Estimated Downstream Horizontal Corrector Strength Requirement vs. y



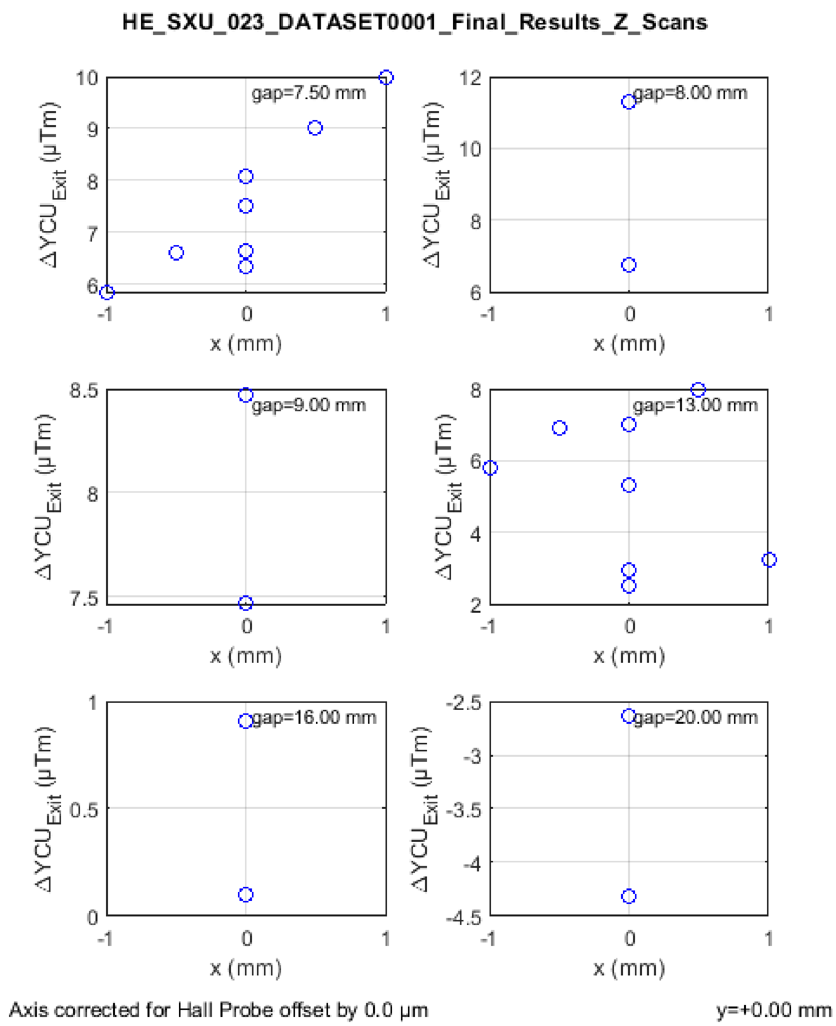
The figure shows the required strength of the upstream horizontal corrector to remove the first vertical undulator and upstream corrector field integrals at the downstream BPM for a number of operational undulator gaps. The analysis was done at a number of off-axis locations in the y-z plane. All values are small and well below the maximum correction amplitude of greater than 550 μTm capabilities of the actual correctors.

Estimated Upstream Vertical Corrector Strength Requirement vs. x



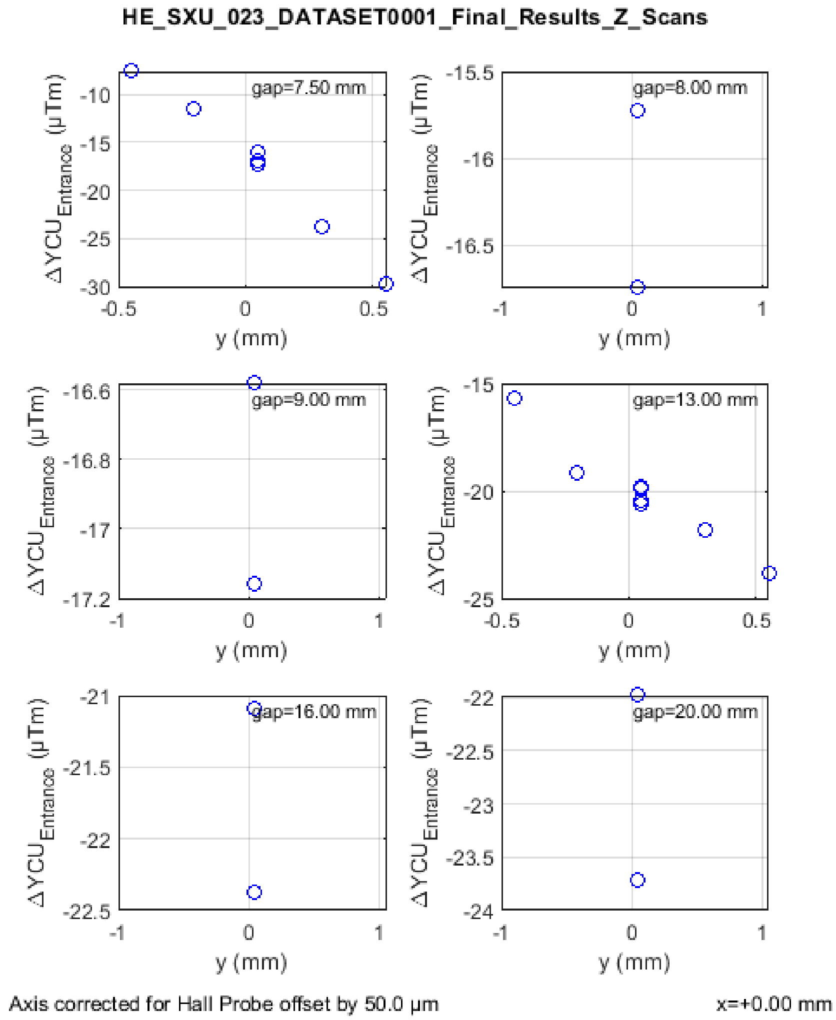
The figure shows the required strength of the upstream horizontal corrector to remove the second horizontal undulator field integral at the downstream BPM for a number of operational undulator gaps. The analysis was done at a number of off-axis locations in the x-z plane. All values are small and well below the maximum correction capabilities of greater than 550 μTm of the actual correctors.

Estimated Downstream Vertical Corrector Strength Requirement vs. x



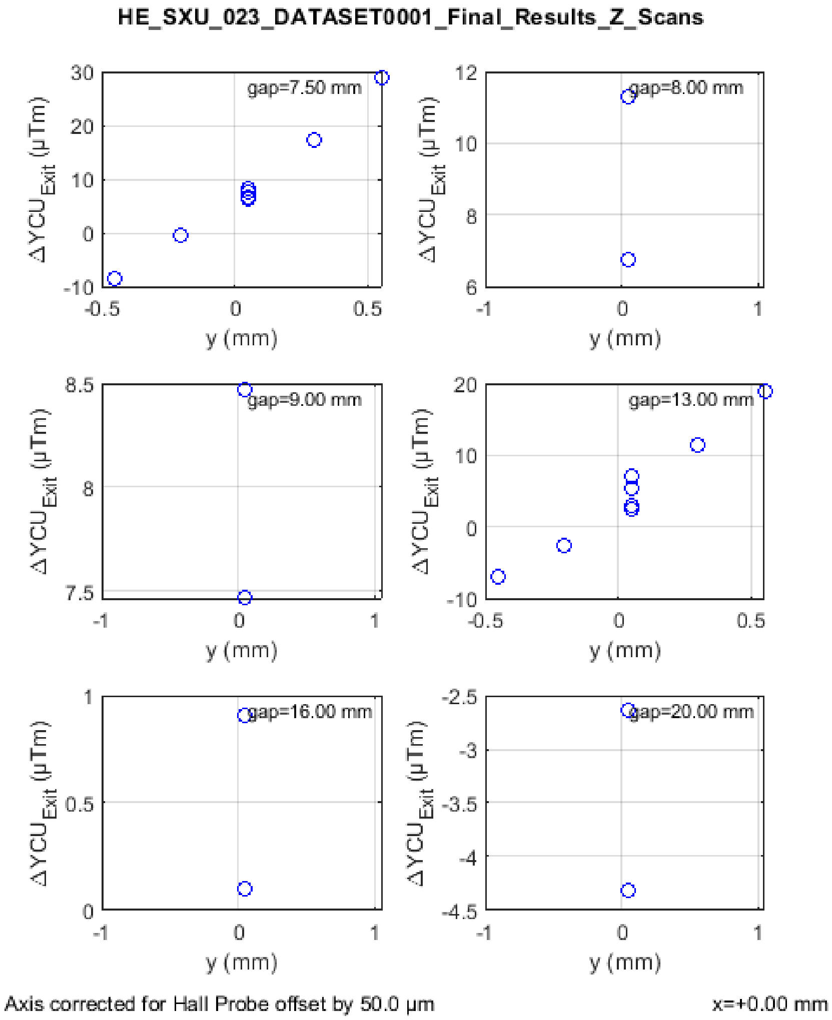
The figure shows the required strength of the downstream vertical corrector to remove the first horizontal undulator field integral and upstream corrector field integral at the downstream BPM for a number of operational undulator gaps. The analysis was done at a number of off-axis locations in the x-z plane. All values are small and well below the maximum correction capabilities of greater than 550 μTm of the actual correctors.

Estimated Upstream Vertical Corrector Strength Requirement vs. y



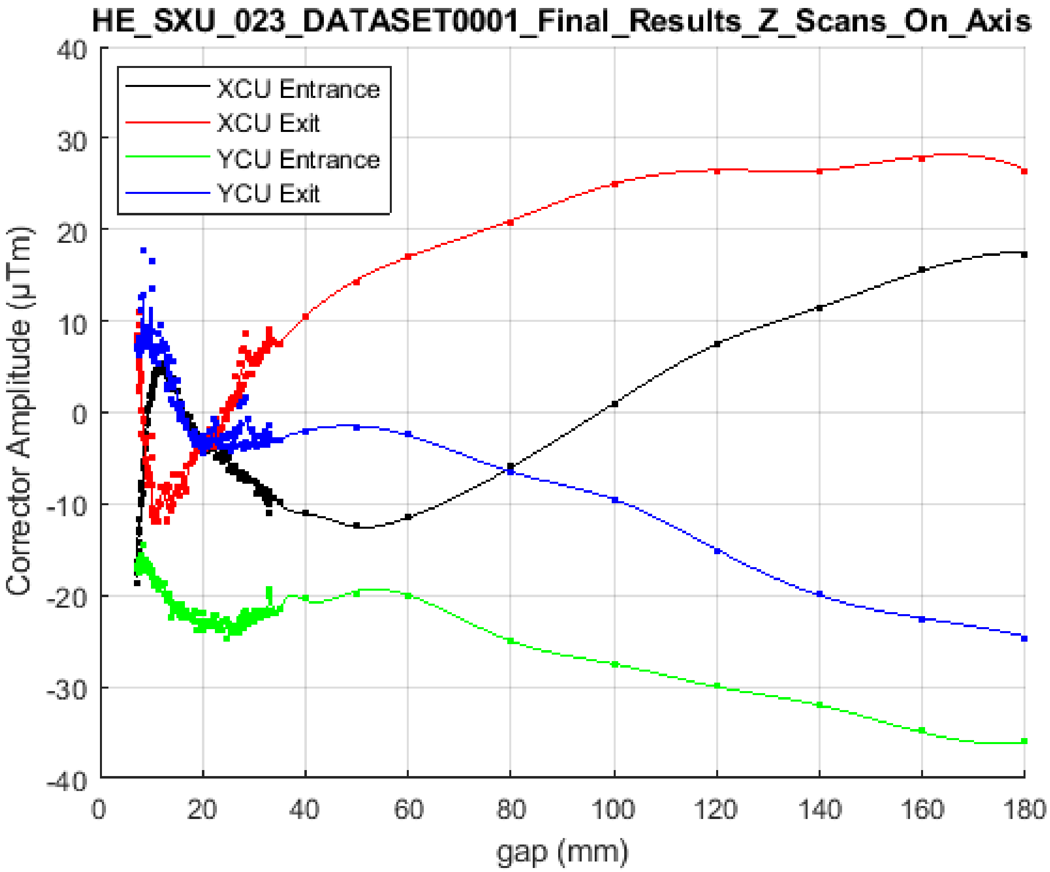
The figure shows the required strength of the upstream vertical corrector to remove the second horizontal undulator field integral at the downstream BPM for a number of operational undulator gaps. The analysis was done at a number of off-axis locations in the y-z plane. All values are small and well below the maximum correction capabilities of greater than 550 μTm of the actual correctors.

Estimated Downstream Vertical Corrector Strength Requirement vs. y



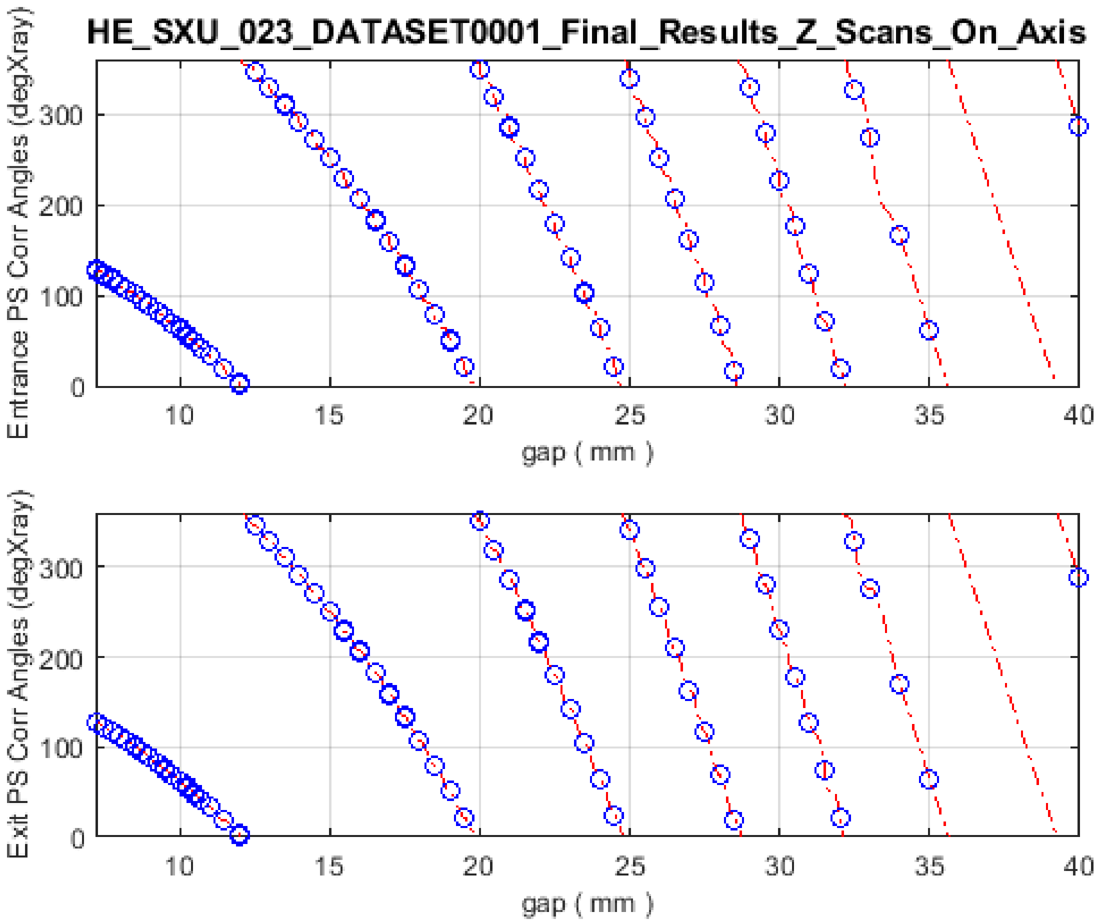
The figure shows the required strength of the downstream vertical corrector to remove the first horizontal undulator field integral and the upstream corrector field integral at the downstream BPM for a number of operational undulator gaps. The analysis was done at a number of off-axis locations in the y-z plane. All values are small and well below the maximum correction capabilities of greater than 550 μTm of the actual correctors.

Estimated Corrector Strengths Requirement vs. gap



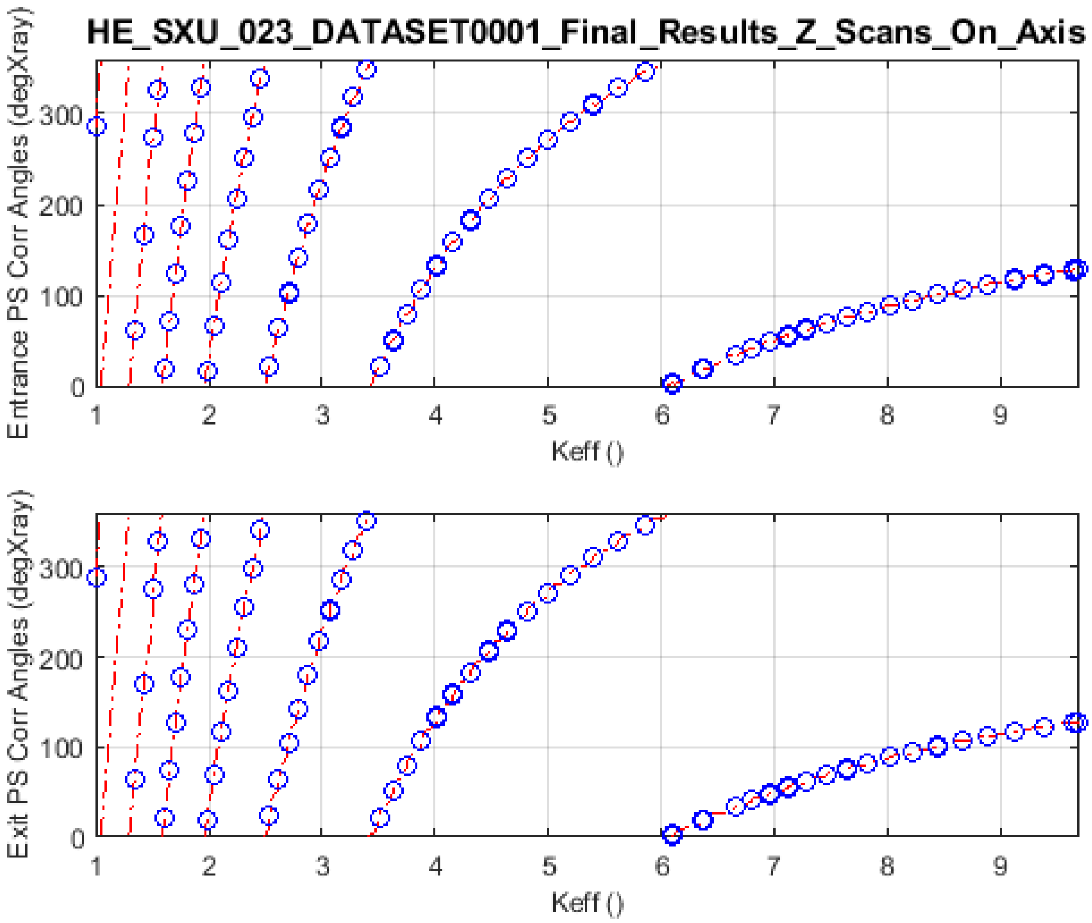
The figure shows as a function of undulator gap the required strengths of the upstream and downstream horizontal and vertical correctors to remove the effect of undulator field integrals at the downstream BPM over the entire available gap range. All values are small and well below the maximum correction capabilities of greater than 550 μTm of the actual correctors.

Measured Undulator Entrance and Exit Phase Delays vs. gap



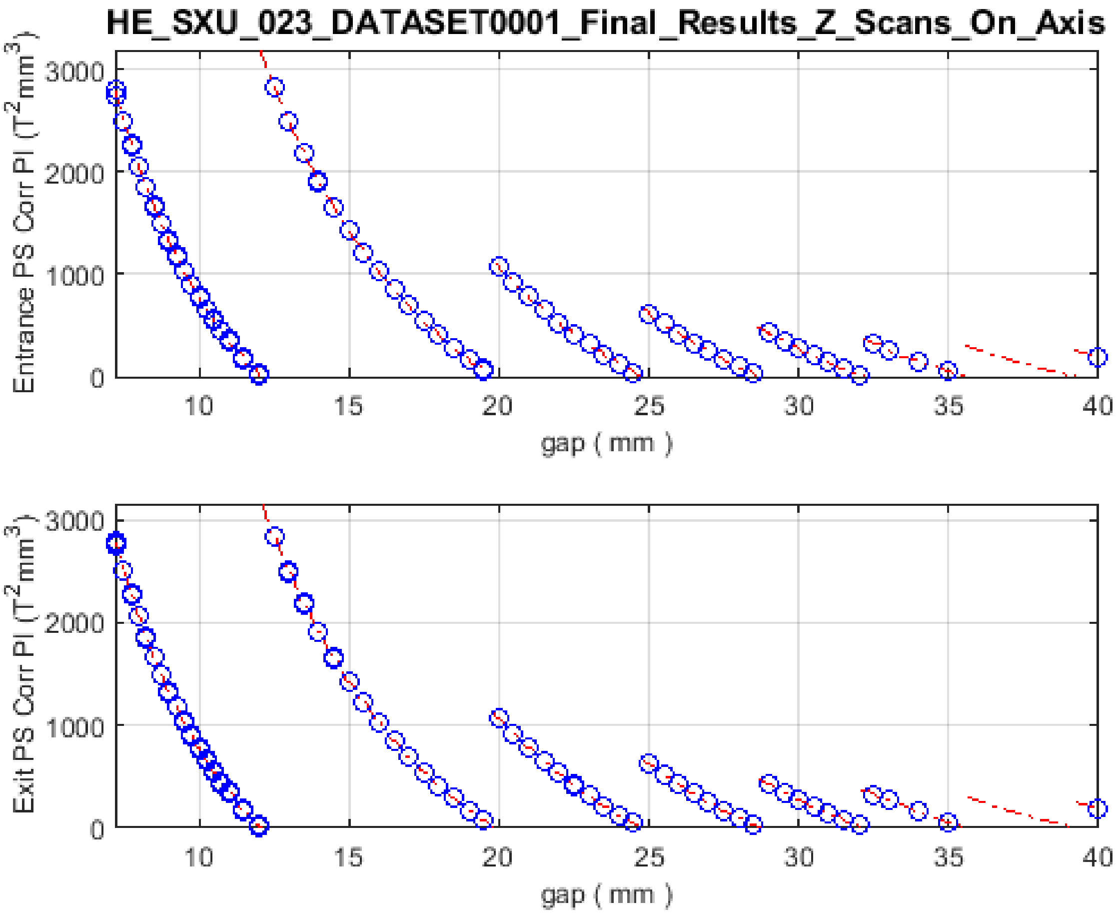
The two figures show, as a function of undulator gap, the phase delays generated by the undulator entrance and exit sections (as calculated by Eqs. 2 and 3 show on page 21), respectively, as red dash—dotted lines. The blue circles indicate MMF measurements.
Note: The break-ups of the function are just for fitting it into the 0 - 360 degXray range, they are not related to the phaseshifter resets needed during operations.

Measured Undulator Entrance and Exit Phase Delays vs. K_{eff}



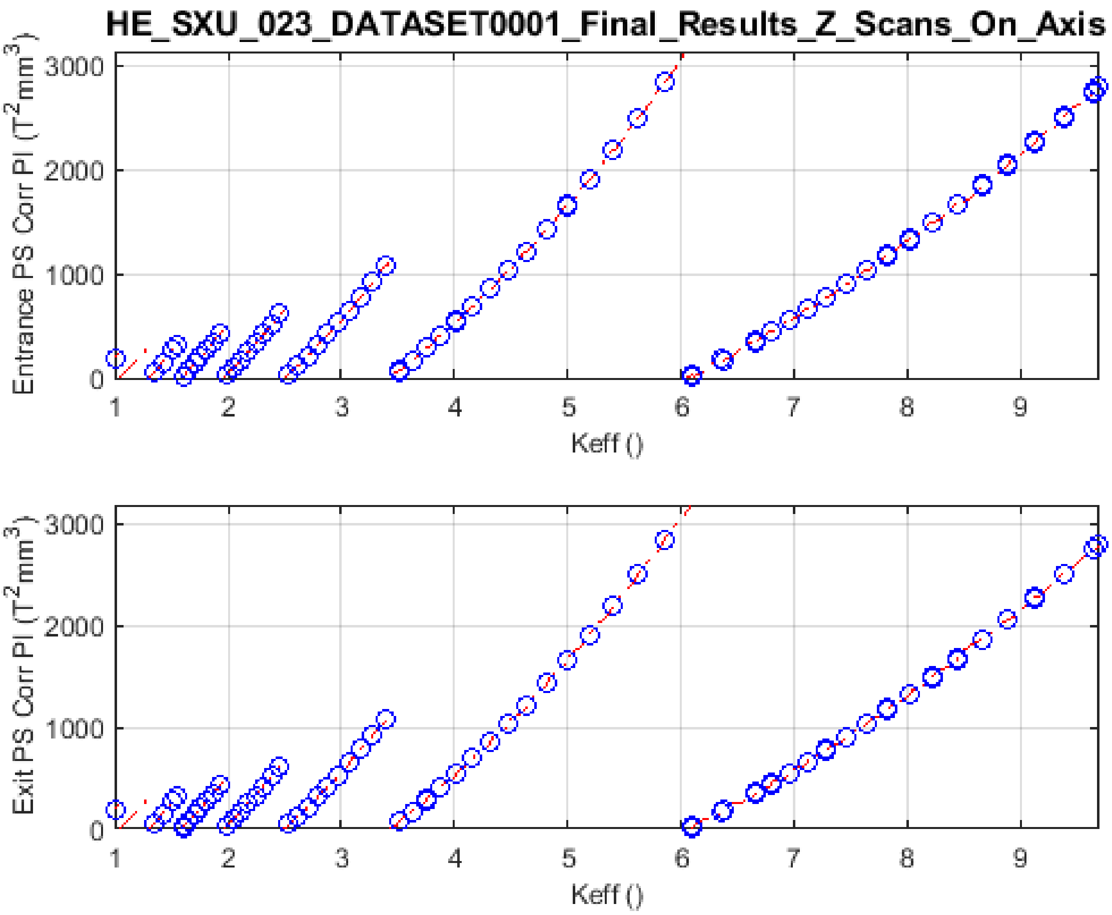
The two figures show, as a function of undulator parameter, K_{eff}, the phase delays generated by the undulator entrance and exit sections (as calculated by Eqs. 2 and 3 shown on page 21), respectively, as red dash—dotted lines. The blue circles indicate MMF measurements.
Note: The break-ups of the function are just for fitting it into the 0 - 360 degXray range, they are not related to the phaseshifter resets needed during operations.

Phase Integrals from Undulator Entrance and Exit Phase Delays vs. gap



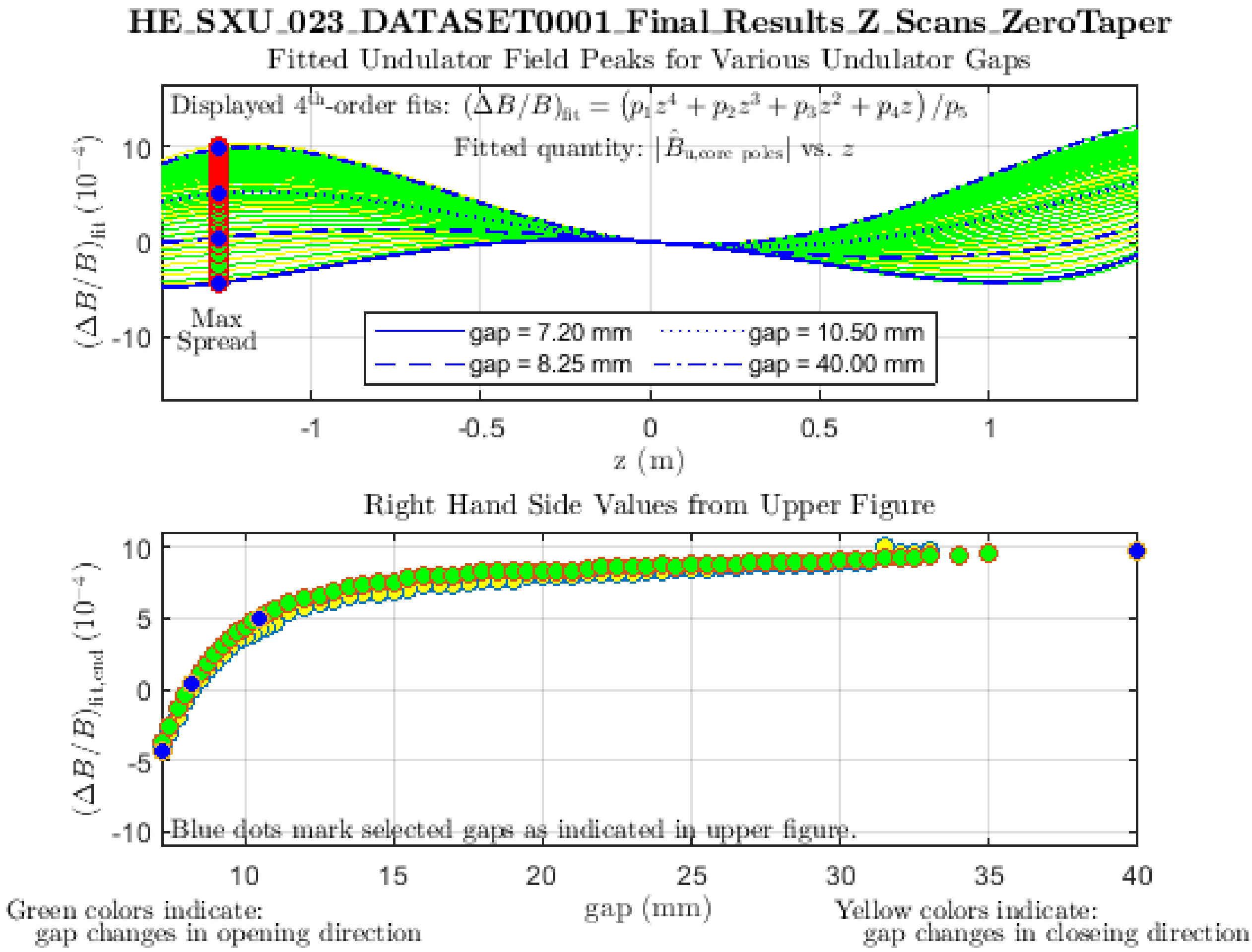
The two figures show, as a function of undulator gap, the phase integral (PI) values correcponding to the phase delay angles shown in the figures on page 38. The red dash—dotted lines and the blue circles indicate MMF measurements corresponds to the same symbols in the figures on page 38.

Phase Integrals from Undulator Entrance and Exit Phase Delays vs. K_{eff}



The two figures show, as a function of undulator K_{eff}, the phase integral (PI) values correcponding to the phase delay angles shown in the figures on page 39. The red dash—dotted lines and the blue circles indicate MMF measurements corresponds to the same symbols in the figures on page 39.

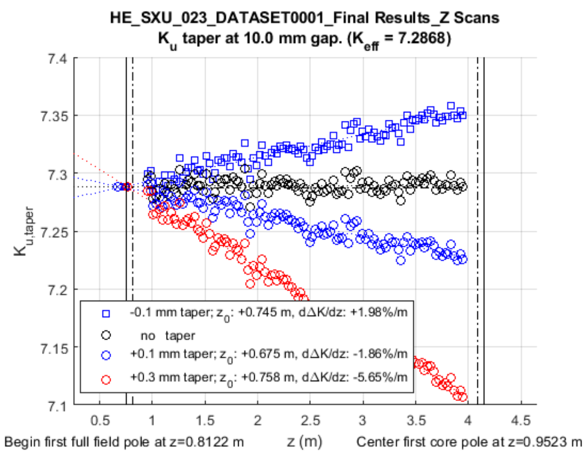
Zero Taper Fit vs. gap

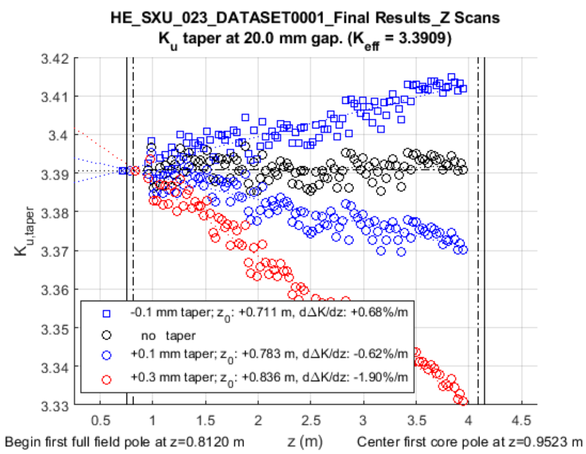


The top figure shows 4th order fits ($B_{\rm fit}(z) = p_1 \times z^4 + p_2 \times z^3 + p_3 \times z^2 + p_4 \times z + p_5$) to the absolute peak values, $\hat{B}_u$, for each core pole for different gaps when the device is set to zero taper. Plotted are $B_{\rm fit}(z)/p_5 - 1$. Green curves indicate that the gap was approached from smaller gaps, while yellow curves indicate approach from larger gaps. The $B_{\rm fit}(z)/p_5 - 1$ value at the z-position, where the spread is largest is marked with a solid circle with the same color coding. The bottom figure shows the same solid circles as in the upper plot but this time plotted against the corresponding undulator gap values. As expected, the figures show that the undulator has a small 4th order taper that varies with gap. This could explain the phase shake dependence on gap as shown in an earlier figure (see page 20).

Gap Tapering—Tapered K_u Values

The SXU devices support a gap taper, which is controlled by the taper PV, which holds the difference between the upstream and downstream gap encoder readings measured in micro-meter. The taper can be varied over the ± 300 μm-range.

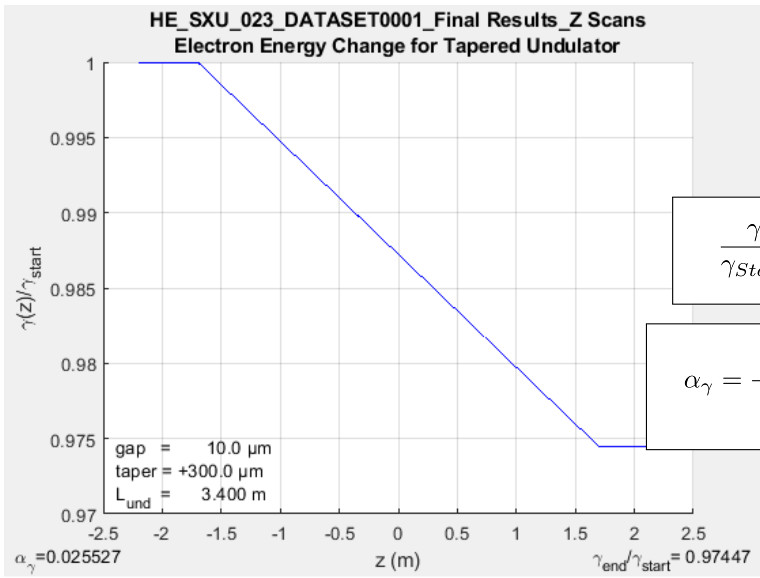




The figure shows K_u, taper for the 108 core poles based on Hall probe measurements versus z location for 4 different taper amplitudes (-100 μm, 0 μm, +100 μm, +300 μm) and 2 different gaps (8 mm, 22 mm). The vertical dashed lines indicate the beginning of the first and the end of the last full field pole. The solid vertical lines indicate the longitudinal limits of strongback. The crosses on the left hand side of the undulator segment border surrounded by the K_u, taper symbol for the representative taper amplitude indicate the intersections between linear fits (indicated by dotted lines in the representative color) and the K_u values untapered case with each of the tapered cases. The horizontal dash—dotted line next to the figure center (hard to see) indicated the level of K_{eff} of the untapered undulator.
The taper operation for this segment is functional.

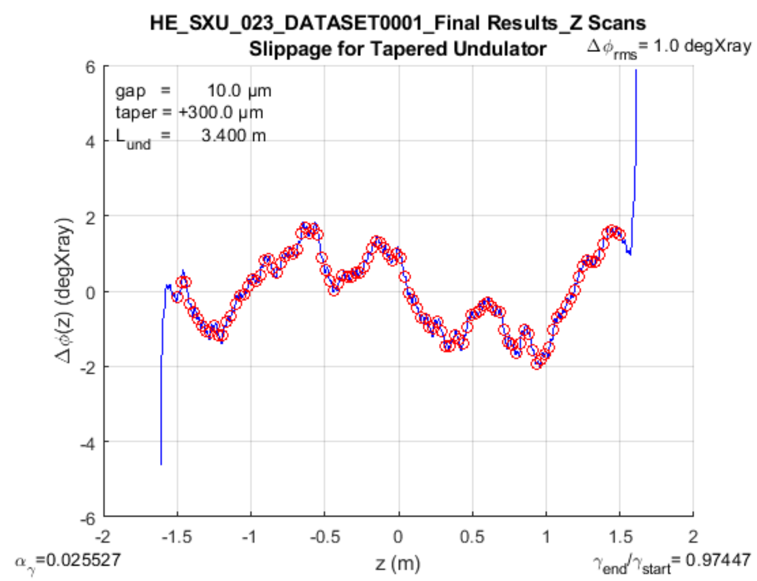
Gap Tapering—Tapered K_u Values

Generally, gap tapering will cause significant increases in the phase shake within the undulator segment. If however during high gain FEL operation the electrons loose significant amounts of energy, a matching gap taper can reduce the total phase shake to stay within the original parallel gap phase shake tolerance for constant energy.



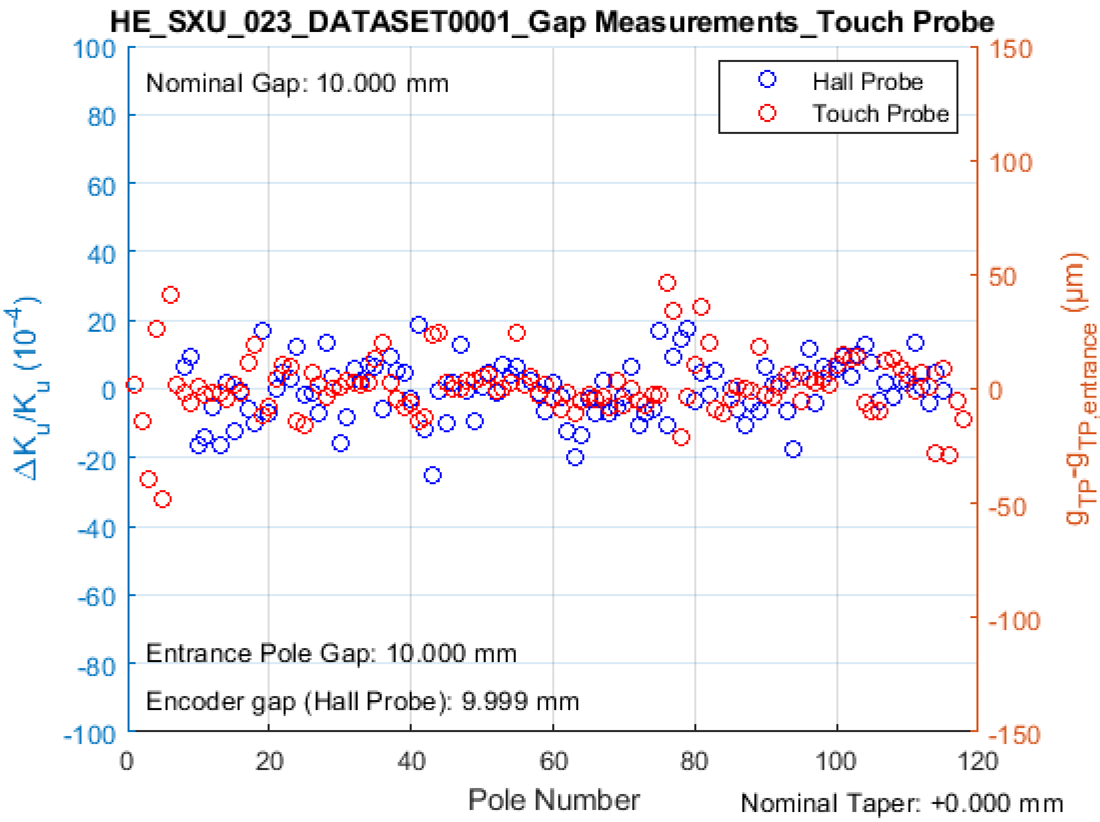
$$\frac{\gamma}{\gamma_{Start}} = 1 - \alpha_\gamma \frac{z}{L_{und}}$$

$$\alpha_\gamma = -\frac{1}{\frac{2}{K_0^2}+1}\frac{L_{und}}{K_0}\frac{dK}{dz}$$



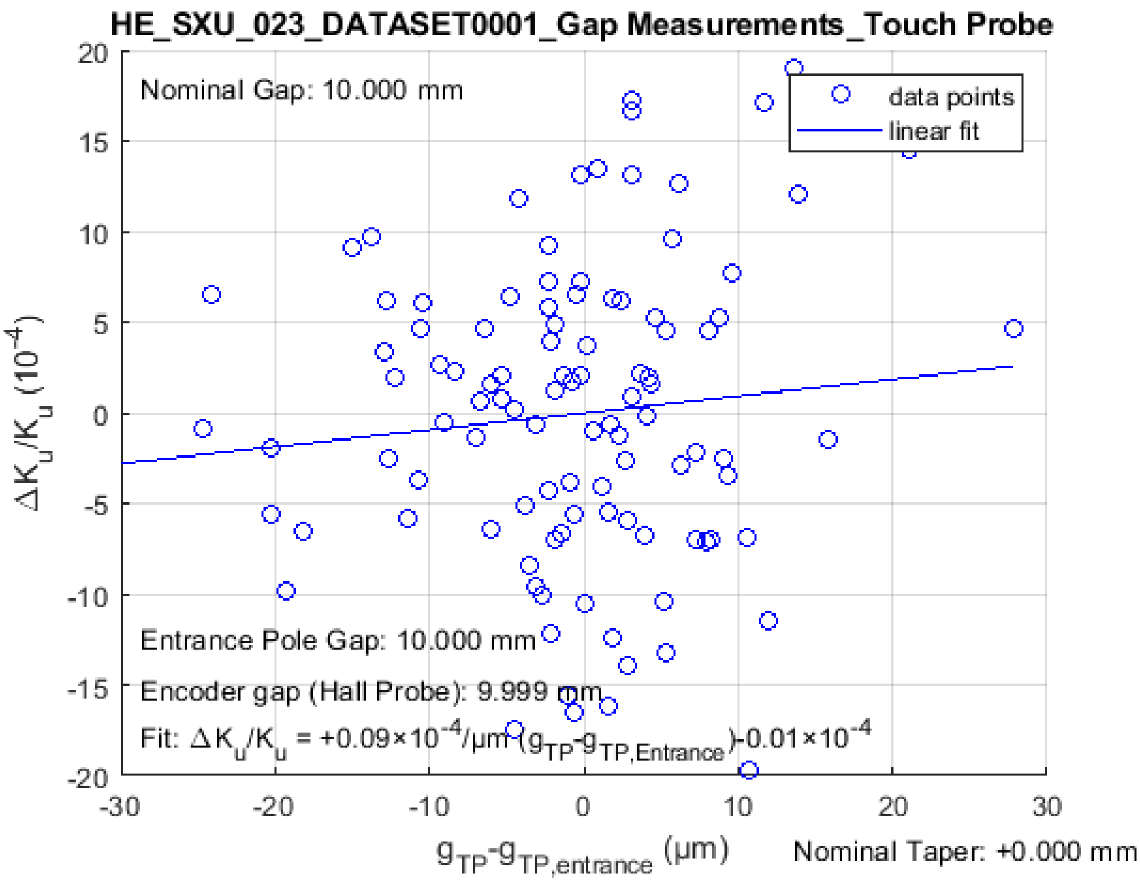
The upper figure shows a simplified linear energy loss function (Lorentz factor γ/γ_{Start}) optimized for the 0.3 mm gap taper at an 10 mm nominal gap. The lower figure shows the phase error along the undulator segment for the same parameters.

Touch Probe (TP) Analysis — Per pole gap vs. per pole K (untapered)



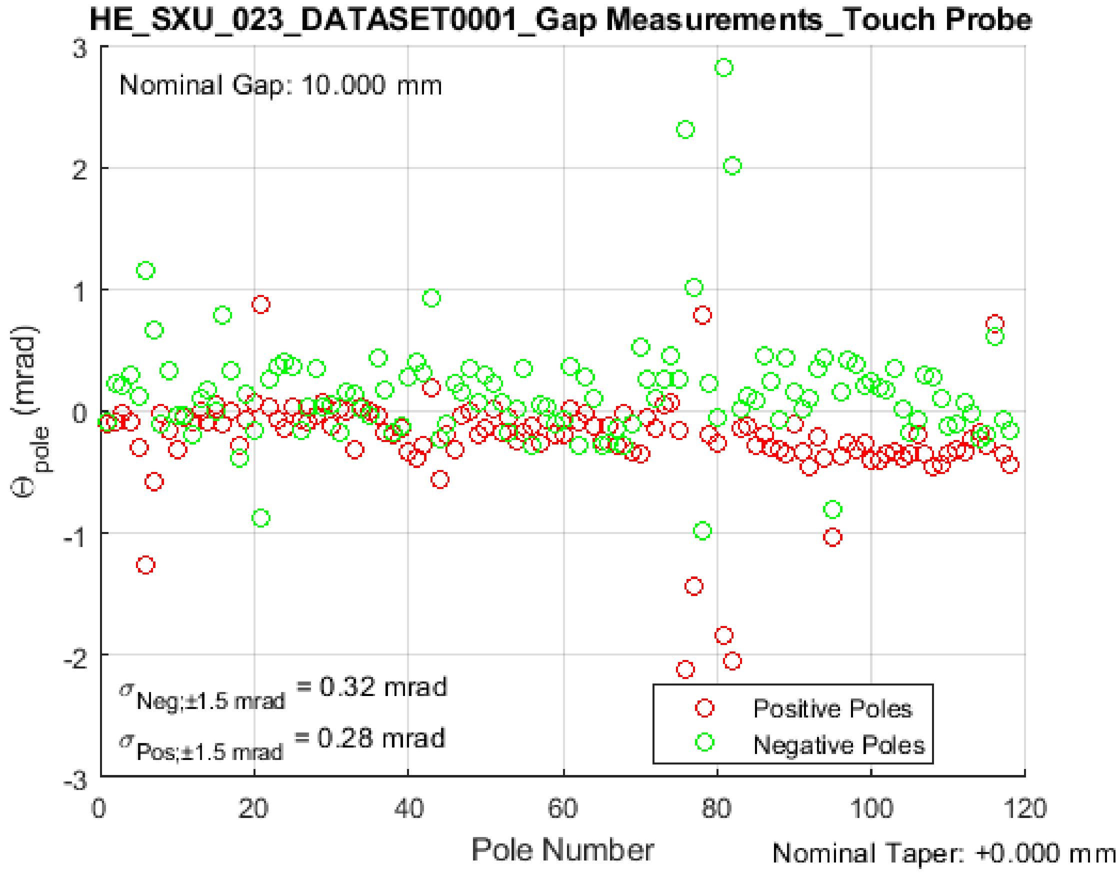
The figure shows $\Delta K/K$ (blue, left axis) (for the 108 core poles) as well as mechanical gap heights ($\langle g_{TP} \rangle - g_{TP}$) (red, right axis) (for all 122 poles) based on touch probe measurements versus pole number. The large amplitude outliers are the result of tuning.

Touch Probe (TP) Analysis — K vs. per pole gap (untapered)



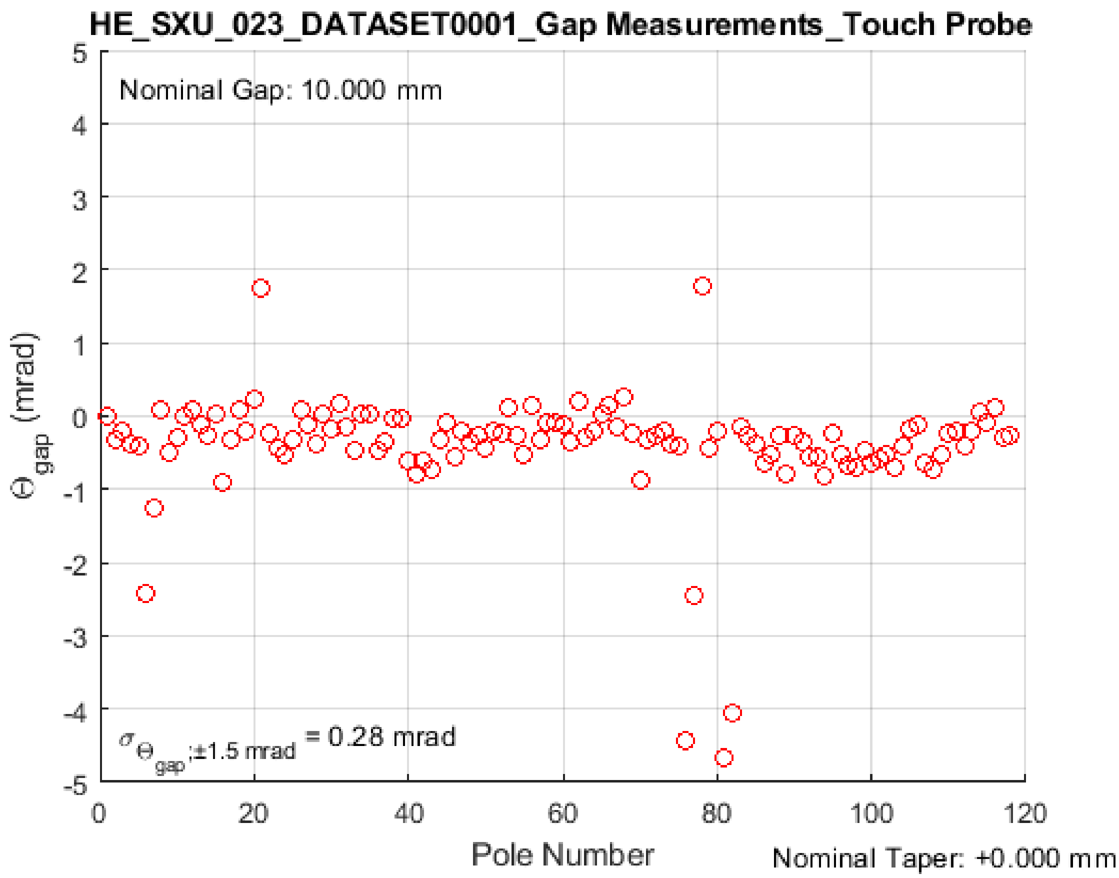
The figure shows the correlation between the $\Delta K_u/K_u$ for each pole from Hall probe measurements for the tuning gap and the deviation of the pole gap measured by the touch probe relative to its average (for the 108 core poles). The average gap measured with the touch probe and the one measured with the gap encoder are shown in the lower left corner of the figure. Also shown is the fit function.

Touch Probe (TP) Analysis — Pole Cant Angles (untapered)



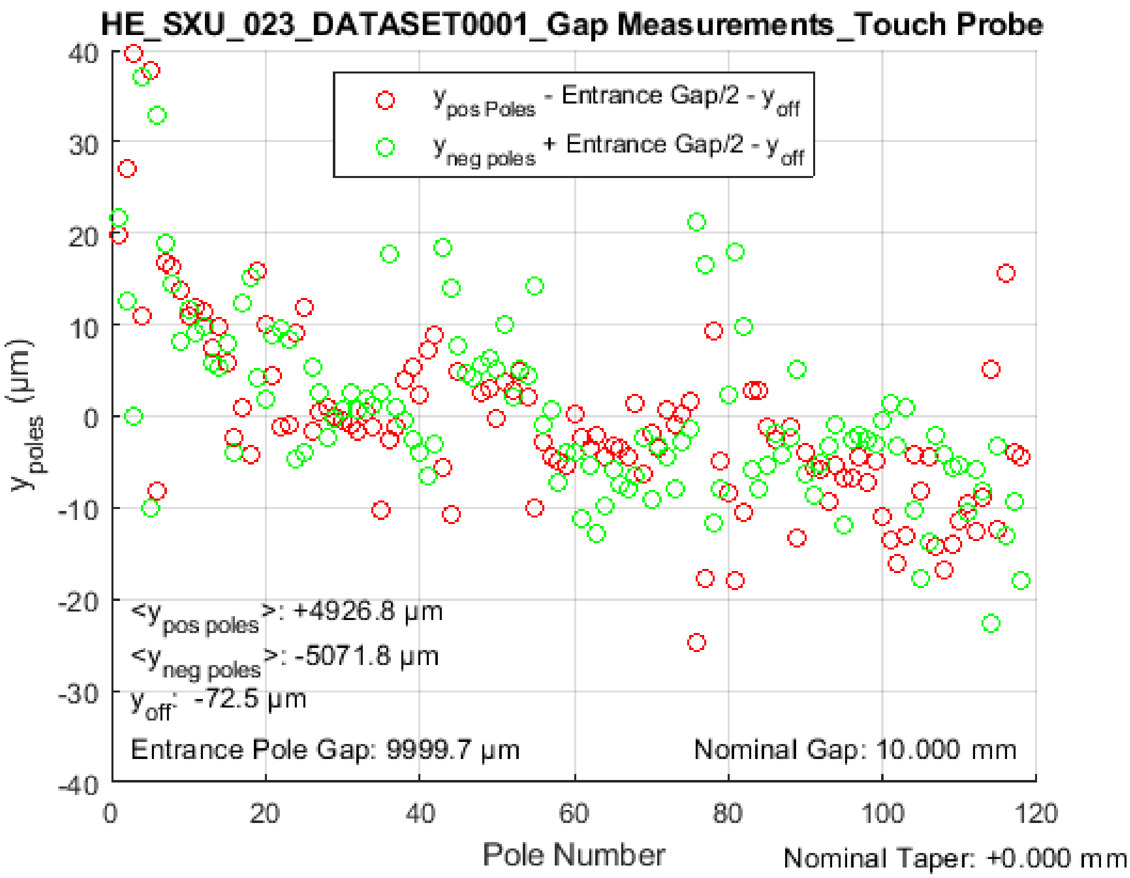
The figure shows the cant angles of each pole (top red, bottom green) relative to the horizontal plane defined by the Kugler bench at the Tuning Gap for all 122 poles, measured by the touch probe. The rms width of each distribution within a ±1.5 mrad band is shown in the lower left corner of the figure.

Touch Probe (TP) Analysis — Gap Cant Angles (untapered)



The figure shows the cant angles between the top and bottom part of each pole at the Tuning Gap for all 122 poles, measured by the touch probe. The rms width of each distribution within a ±1.5 mrad band is shown in the lower left corner of the figure.

Touch Probe (TP) Analysis — Pole Heights (untapered)



The figure shows the relative vertial positions of the center of each pole (top red, bottom green) relative to the horizontal plane defined by the Kugler bench at the Tuning Gap for all 122 poles, measured by the touch probe.

Measurement Results are stored:

At V-Drive:

☒ V:\MET\MagServe\MagData\LCLS-II-HE\Undulator\

☐ ______________________________

In Folder

☒ HE_SXU_023\DATASET0001\Final Results\

☐ ______________________________

Confirmation of File Locations:

The following tables list all required data files documenting the calibration results. An existence check was done and the result is indicated next to each filename as "exists" or "missing".

Sub folder: Z Scans\Good Field Region exists

005gap007.500x-01.00y+00.00\zscan.dat	exists
004gap007.500x-00.50y+00.00\zscan.dat	exists
003gap007.500x+00.00y+00.00\zscan.dat	exists
002gap007.500x+00.50y+00.00\zscan.dat	exists
001gap007.500x+01.00y+00.00\zscan.dat	exists
006gap007.500x+00.00y-00.50\zscan.dat	exists
007gap007.500x+00.00y-00.25\zscan.dat	exists
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076gap033.000x+00.00y-00.50\zscan.dat	exists
077gap033.000x+00.00y-00.25\zscan.dat	exists
079gap033.000x+00.00y+00.25\zscan.dat	exists
080gap033.000x+00.00y+00.50\zscan.dat	exists

Sub folder: Z Scans\On Axis exists

001gap007.200x+00.00y+00.00\zscan.dat	exists
002gap007.250x+00.00y+00.00\zscan.dat	exists
003gap007.500x+00.00y+00.00\zscan.dat	exists
004gap007.750x+00.00y+00.00\zscan.dat	exists
005gap008.000x+00.00y+00.00\zscan.dat	exists
006gap008.250x+00.00y+00.00\zscan.dat	exists
007gap008.500x+00.00y+00.00\zscan.dat	exists
008gap008.750x+00.00y+00.00\zscan.dat	exists
009gap009.000x+00.00y+00.00\zscan.dat	exists
010gap009.250x+00.00y+00.00\zscan.dat	exists
011gap009.500x+00.00y+00.00\zscan.dat	exists
012gap009.750x+00.00y+00.00\zscan.dat	exists
013gap010.000x+00.00y+00.00\zscan.dat	exists
014gap010.250x+00.00y+00.00\zscan.dat	exists
015gap010.500x+00.00y+00.00\zscan.dat	exists

016gap010.750x+00.00y+00.00\zscan.dat	exists
017gap011.000x+00.00y+00.00\zscan.dat	exists
018gap011.500x+00.00y+00.00\zscan.dat	exists
019gap012.000x+00.00y+00.00\zscan.dat	exists
020gap012.500x+00.00y+00.00\zscan.dat	exists
021gap013.000x+00.00y+00.00\zscan.dat	exists
022gap013.500x+00.00y+00.00\zscan.dat	exists
023gap014.000x+00.00y+00.00\zscan.dat	exists
024gap014.500x+00.00y+00.00\zscan.dat	exists
025gap015.000x+00.00y+00.00\zscan.dat	exists
026gap015.500x+00.00y+00.00\zscan.dat	exists
027gap016.000x+00.00y+00.00\zscan.dat	exists
028gap016.500x+00.00y+00.00\zscan.dat	exists
029gap017.000x+00.00y+00.00\zscan.dat	exists
030gap017.500x+00.00y+00.00\zscan.dat	exists
031gap018.000x+00.00y+00.00\zscan.dat	exists
032gap018.500x+00.00y+00.00\zscan.dat	exists
033gap019.000x+00.00y+00.00\zscan.dat	exists
034gap019.500x+00.00y+00.00\zscan.dat	exists
035gap020.000x+00.00y+00.00\zscan.dat	exists
036gap020.500x+00.00y+00.00\zscan.dat	exists
037gap021.000x+00.00y+00.00\zscan.dat	exists
038gap021.500x+00.00y+00.00\zscan.dat	exists
039gap022.000x+00.00y+00.00\zscan.dat	exists
040gap022.500x+00.00y+00.00\zscan.dat	exists
041gap023.000x+00.00y+00.00\zscan.dat	exists
042gap023.500x+00.00y+00.00\zscan.dat	exists
043gap024.000x+00.00y+00.00\zscan.dat	exists
044gap024.500x+00.00y+00.00\zscan.dat	exists
045gap025.000x+00.00y+00.00\zscan.dat	exists
046gap025.500x+00.00y+00.00\zscan.dat	exists
047gap026.000x+00.00y+00.00\zscan.dat	exists
048gap026.500x+00.00y+00.00\zscan.dat	exists
049gap027.000x+00.00y+00.00\zscan.dat	exists
050gap027.500x+00.00y+00.00\zscan.dat	exists
051gap028.000x+00.00y+00.00\zscan.dat	exists

052gap028.500x+00.00y+00.00\zscan.dat	exists
053gap029.000x+00.00y+00.00\zscan.dat	exists
054gap029.500x+00.00y+00.00\zscan.dat	exists
055gap030.000x+00.00y+00.00\zscan.dat	exists
056gap030.500x+00.00y+00.00\zscan.dat	exists
057gap031.000x+00.00y+00.00\zscan.dat	exists
058gap031.500x+00.00y+00.00\zscan.dat	exists
059gap032.000x+00.00y+00.00\zscan.dat	exists
061gap033.000x+00.00y+00.00\zscan.dat	exists
063gap035.000x+00.00y+00.00\zscan.dat	exists
055gap030.000x+00.00y+00.00\zscan.dat	exists
064gap040.000x+00.00y+00.00\zscan.dat	exists
065gap050.000x+00.00y+00.00\zscan.dat	exists
066gap060.000x+00.00y+00.00\zscan.dat	exists
067gap080.000x+00.00y+00.00\zscan.dat	exists
068gap100.000x+00.00y+00.00\zscan.dat	exists
069gap120.000x+00.00y+00.00\zscan.dat	exists
070gap140.000x+00.00y+00.00\zscan.dat	exists
071gap160.000x+00.00y+00.00\zscan.dat	exists
072gap180.000x+00.00y+00.00\zscan.dat	exists

Sub folder: Z Scans\Commissioning Gap `exists`

001gap016.580x+00.00y+00.00\zscan.dat	exists

Sub folder: Z Scans\Gap with taper `exists`

005gap010.000taper-0.100x+00.00y+00.00\zscan.dat	exists
007gap010.000taper+0.000x+00.00y+00.00\zscan.dat	exists
001gap010.000taper+0.100x+00.00y+00.00\zscan.dat	exists
003gap010.000taper+0.300x+00.00y+00.00\zscan.dat	exists
006gap020.000taper-0.100x+00.00y+00.00\zscan.dat	exists
008gap020.000taper+0.000x+00.00y+00.00\zscan.dat	exists
002gap020.000taper+0.100x+00.00y+00.00\zscan.dat	exists
004gap020.000taper+0.300x+00.00y+00.00\zscan.dat	exists

Sub folder: Long Coil exists

Sub folder: Long Coil\Good Field Region exists

integrals_summary.txt	exists
015gap007.500x-01.00y+00.00_i1X_integrals.txt	exists
014gap007.500x-00.50y+00.00_i1X_integrals.txt	exists
013gap007.500x+00.00y+00.00_i1X_integrals.txt	exists
012gap007.500x+00.50y+00.00_i1X_integrals.txt	exists
011gap007.500x+01.00y+00.00_i1X_integrals.txt	exists
031gap007.500x+00.00y-01.00_i1X_integrals.txt	exists
035gap007.500x+00.00y+01.00_i1X_integrals.txt	exists
055gap008.500x-01.00y+00.00_i1X_integrals.txt	exists
054gap008.500x-00.50y+00.00_i1X_integrals.txt	exists
053gap008.500x+00.00y+00.00_i1X_integrals.txt	exists
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051gap008.500x+01.00y+00.00_i1X_integrals.txt	exists
071gap008.500x+00.00y-01.00_i1X_integrals.txt	exists
075gap008.500x+00.00y+01.00_i1X_integrals.txt	exists
095gap010.000x-01.00y+00.00_i1X_integrals.txt	exists
094gap010.000x-00.50y+00.00_i1X_integrals.txt	exists
093gap010.000x+00.00y+00.00_i1X_integrals.txt	exists
092gap010.000x+00.50y+00.00_i1X_integrals.txt	exists
091gap010.000x+01.00y+00.00_i1X_integrals.txt	exists
111gap010.000x+00.00y-01.00_i1X_integrals.txt	exists
115gap010.000x+00.00y+01.00_i1X_integrals.txt	exists
135gap013.000x-01.00y+00.00_i1X_integrals.txt	exists
134gap013.000x-00.50y+00.00_i1X_integrals.txt	exists
133gap013.000x+00.00y+00.00_i1X_integrals.txt	exists
132gap013.000x+00.50y+00.00_i1X_integrals.txt	exists
131gap013.000x+01.00y+00.00_i1X_integrals.txt	exists
151gap013.000x+00.00y-01.00_i1X_integrals.txt	exists
155gap013.000x+00.00y+01.00_i1X_integrals.txt	exists
175gap017.000x-01.00y+00.00_i1X_integrals.txt	exists
174gap017.000x-00.50y+00.00_i1X_integrals.txt	exists
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171gap017.000x+01.00y+00.00_i1X_integrals.txt	exists
191gap017.000x+00.00y-01.00_i1X_integrals.txt	exists
195gap017.000x+00.00y+01.00_i1X_integrals.txt	exists
215gap022.000x-01.00y+00.00_i1X_integrals.txt	exists
214gap022.000x-00.50y+00.00_i1X_integrals.txt	exists
213gap022.000x+00.00y+00.00_i1X_integrals.txt	exists
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231gap022.000x+00.00y-01.00_i1X_integrals.txt	exists
235gap022.000x+00.00y+01.00_i1X_integrals.txt	exists
255gap027.000x-01.00y+00.00_i1X_integrals.txt	exists
254gap027.000x-00.50y+00.00_i1X_integrals.txt	exists
253gap027.000x+00.00y+00.00_i1X_integrals.txt	exists
252gap027.000x+00.50y+00.00_i1X_integrals.txt	exists
251gap027.000x+01.00y+00.00_i1X_integrals.txt	exists
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275gap027.000x+00.00y+01.00_i1X_integrals.txt	exists
295gap033.000x-01.00y+00.00_i1X_integrals.txt	exists
294gap033.000x-00.50y+00.00_i1X_integrals.txt	exists
293gap033.000x+00.00y+00.00_i1X_integrals.txt	exists
292gap033.000x+00.50y+00.00_i1X_integrals.txt	exists
291gap033.000x+01.00y+00.00_i1X_integrals.txt	exists
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335gap100.000x-01.00y+00.00_i1X_integrals.txt	exists
334gap100.000x-00.50y+00.00_i1X_integrals.txt	exists
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331gap100.000x+01.00y+00.00_i1X_integrals.txt	exists
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020gap007.500x-01.00y+00.00_i2X_integrals.txt	exists
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059gap008.500x-00.50y+00.00_i2X_integrals.txt	exists
058gap008.500x+00.00y+00.00_i2X_integrals.txt	exists
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080gap008.500x+00.00y+01.00_i2X_integrals.txt	exists
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099gap010.000x-00.50y+00.00_i2X_integrals.txt	exists
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180gap017.000x-01.00y+00.00_i2X_integrals.txt	exists
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169gap017.000x-00.50y+00.00_i2Y_integrals.txt	exists
168gap017.000x+00.00y+00.00_i2Y_integrals.txt	exists
167gap017.000x+00.50y+00.00_i2Y_integrals.txt	exists
166gap017.000x+01.00y+00.00_i2Y_integrals.txt	exists
186gap017.000x+00.00y-01.00_i2Y_integrals.txt	exists
190gap017.000x+00.00y+01.00_i2Y_integrals.txt	exists
210gap022.000x-01.00y+00.00_i2Y_integrals.txt	exists
209gap022.000x-00.50y+00.00_i2Y_integrals.txt	exists
208gap022.000x+00.00y+00.00_i2Y_integrals.txt	exists
207gap022.000x+00.50y+00.00_i2Y_integrals.txt	exists
206gap022.000x+01.00y+00.00_i2Y_integrals.txt	exists
226gap022.000x+00.00y-01.00_i2Y_integrals.txt	exists
230gap022.000x+00.00y+01.00_i2Y_integrals.txt	exists
250gap027.000x-01.00y+00.00_i2Y_integrals.txt	exists
249gap027.000x-00.50y+00.00_i2Y_integrals.txt	exists
248gap027.000x+00.00y+00.00_i2Y_integrals.txt	exists
247gap027.000x+00.50y+00.00_i2Y_integrals.txt	exists
246gap027.000x+01.00y+00.00_i2Y_integrals.txt	exists
266gap027.000x+00.00y-01.00_i2Y_integrals.txt	exists
270gap027.000x+00.00y+01.00_i2Y_integrals.txt	exists
290gap033.000x-01.00y+00.00_i2Y_integrals.txt	exists
289gap033.000x-00.50y+00.00_i2Y_integrals.txt	exists
288gap033.000x+00.00y+00.00_i2Y_integrals.txt	exists
287gap033.000x+00.50y+00.00_i2Y_integrals.txt	exists
286gap033.000x+01.00y+00.00_i2Y_integrals.txt	exists
306gap033.000x+00.00y-01.00_i2Y_integrals.txt	exists
310gap033.000x+00.00y+01.00_i2Y_integrals.txt	exists
330gap100.000x-01.00y+00.00_i2Y_integrals.txt	exists
329gap100.000x-00.50y+00.00_i2Y_integrals.txt	exists
328gap100.000x+00.00y+00.00_i2Y_integrals.txt	exists

327gap100.000x+00.50y+00.00_i2Y_integrals.txt	exists
326gap100.000x+01.00y+00.00_i2Y_integrals.txt	exists
346gap100.000x+00.00y-01.00_i2Y_integrals.txt	exists
350gap100.000x+00.00y+01.00_i2Y_integrals.txt	exists

Sub folder: Long Coil\On Axis exists

integrals_summary.txt	exists
003gap007.200x+00.00y+00.00_i1X_integrals.txt	exists
004gap007.200x+00.00y+00.00_i2X_integrals.txt	exists
001gap007.200x+00.00y+00.00_i1Y_integrals.txt	exists
002gap007.200x+00.00y+00.00_i2Y_integrals.txt	exists
007gap008.000x+00.00y+00.00_i1X_integrals.txt	exists
008gap008.000x+00.00y+00.00_i2X_integrals.txt	exists
005gap008.000x+00.00y+00.00_i1Y_integrals.txt	exists
006gap008.000x+00.00y+00.00_i2Y_integrals.txt	exists
011gap009.000x+00.00y+00.00_i1X_integrals.txt	exists
012gap009.000x+00.00y+00.00_i2X_integrals.txt	exists
009gap009.000x+00.00y+00.00_i1Y_integrals.txt	exists
010gap009.000x+00.00y+00.00_i2Y_integrals.txt	exists
015gap010.000x+00.00y+00.00_i1X_integrals.txt	exists
016gap010.000x+00.00y+00.00_i2X_integrals.txt	exists
013gap010.000x+00.00y+00.00_i1Y_integrals.txt	exists
014gap010.000x+00.00y+00.00_i2Y_integrals.txt	exists
019gap011.000x+00.00y+00.00_i1X_integrals.txt	exists
020gap011.000x+00.00y+00.00_i2X_integrals.txt	exists
017gap011.000x+00.00y+00.00_i1Y_integrals.txt	exists
018gap011.000x+00.00y+00.00_i2Y_integrals.txt	exists
023gap012.000x+00.00y+00.00_i1X_integrals.txt	exists
024gap012.000x+00.00y+00.00_i2X_integrals.txt	exists
021gap012.000x+00.00y+00.00_i1Y_integrals.txt	exists
022gap012.000x+00.00y+00.00_i2Y_integrals.txt	exists
027gap013.000x+00.00y+00.00_i1X_integrals.txt	exists
028gap013.000x+00.00y+00.00_i2X_integrals.txt	exists
025gap013.000x+00.00y+00.00_i1Y_integrals.txt	exists

026gap013.000x+00.00y+00.00_i2Y_integrals.txt	exists
031gap014.000x+00.00y+00.00_i1X_integrals.txt	exists
032gap014.000x+00.00y+00.00_i2X_integrals.txt	exists
029gap014.000x+00.00y+00.00_i1Y_integrals.txt	exists
030gap014.000x+00.00y+00.00_i2Y_integrals.txt	exists
035gap016.000x+00.00y+00.00_i1X_integrals.txt	exists
036gap016.000x+00.00y+00.00_i2X_integrals.txt	exists
033gap016.000x+00.00y+00.00_i1Y_integrals.txt	exists
034gap016.000x+00.00y+00.00_i2Y_integrals.txt	exists
039gap018.000x+00.00y+00.00_i1X_integrals.txt	exists
040gap018.000x+00.00y+00.00_i2X_integrals.txt	exists
037gap018.000x+00.00y+00.00_i1Y_integrals.txt	exists
038gap018.000x+00.00y+00.00_i2Y_integrals.txt	exists
043gap020.000x+00.00y+00.00_i1X_integrals.txt	exists
044gap020.000x+00.00y+00.00_i2X_integrals.txt	exists
041gap020.000x+00.00y+00.00_i1Y_integrals.txt	exists
042gap020.000x+00.00y+00.00_i2Y_integrals.txt	exists
047gap022.000x+00.00y+00.00_i1X_integrals.txt	exists
048gap022.000x+00.00y+00.00_i2X_integrals.txt	exists
045gap022.000x+00.00y+00.00_i1Y_integrals.txt	exists
046gap022.000x+00.00y+00.00_i2Y_integrals.txt	exists
051gap024.000x+00.00y+00.00_i1X_integrals.txt	exists
052gap024.000x+00.00y+00.00_i2X_integrals.txt	exists
049gap024.000x+00.00y+00.00_i1Y_integrals.txt	exists
050gap024.000x+00.00y+00.00_i2Y_integrals.txt	exists
055gap027.000x+00.00y+00.00_i1X_integrals.txt	exists
056gap027.000x+00.00y+00.00_i2X_integrals.txt	exists
053gap027.000x+00.00y+00.00_i1Y_integrals.txt	exists
054gap027.000x+00.00y+00.00_i2Y_integrals.txt	exists
059gap030.000x+00.00y+00.00_i1X_integrals.txt	exists
060gap030.000x+00.00y+00.00_i2X_integrals.txt	exists
057gap030.000x+00.00y+00.00_i1Y_integrals.txt	exists
058gap030.000x+00.00y+00.00_i2Y_integrals.txt	exists
063gap033.000x+00.00y+00.00_i1X_integrals.txt	exists
064gap033.000x+00.00y+00.00_i2X_integrals.txt	exists
061gap033.000x+00.00y+00.00_i1Y_integrals.txt	exists

062gap033.000x+00.00y+00.00_i2Y_integrals.txt	exists
067gap040.000x+00.00y+00.00_i1X_integrals.txt	exists
068gap040.000x+00.00y+00.00_i2X_integrals.txt	exists
065gap040.000x+00.00y+00.00_i1Y_integrals.txt	exists
066gap040.000x+00.00y+00.00_i2Y_integrals.txt	exists
071gap050.000x+00.00y+00.00_i1X_integrals.txt	exists
072gap050.000x+00.00y+00.00_i2X_integrals.txt	exists
069gap050.000x+00.00y+00.00_i1Y_integrals.txt	exists
070gap050.000x+00.00y+00.00_i2Y_integrals.txt	exists
075gap060.000x+00.00y+00.00_i1X_integrals.txt	exists
076gap060.000x+00.00y+00.00_i2X_integrals.txt	exists
073gap060.000x+00.00y+00.00_i1Y_integrals.txt	exists
074gap060.000x+00.00y+00.00_i2Y_integrals.txt	exists
079gap080.000x+00.00y+00.00_i1X_integrals.txt	exists
080gap080.000x+00.00y+00.00_i2X_integrals.txt	exists
077gap080.000x+00.00y+00.00_i1Y_integrals.txt	exists
078gap080.000x+00.00y+00.00_i2Y_integrals.txt	exists
083gap100.000x+00.00y+00.00_i1X_integrals.txt	exists
084gap100.000x+00.00y+00.00_i2X_integrals.txt	exists
081gap100.000x+00.00y+00.00_i1Y_integrals.txt	exists
082gap100.000x+00.00y+00.00_i2Y_integrals.txt	exists
087gap120.000x+00.00y+00.00_i1X_integrals.txt	exists
088gap120.000x+00.00y+00.00_i2X_integrals.txt	exists
085gap120.000x+00.00y+00.00_i1Y_integrals.txt	exists
086gap120.000x+00.00y+00.00_i2Y_integrals.txt	exists
091gap140.000x+00.00y+00.00_i1X_integrals.txt	exists
092gap140.000x+00.00y+00.00_i2X_integrals.txt	exists
089gap140.000x+00.00y+00.00_i1Y_integrals.txt	exists
090gap140.000x+00.00y+00.00_i2Y_integrals.txt	exists
095gap160.000x+00.00y+00.00_i1X_integrals.txt	exists
096gap160.000x+00.00y+00.00_i2X_integrals.txt	exists
093gap160.000x+00.00y+00.00_i1Y_integrals.txt	exists
094gap160.000x+00.00y+00.00_i2Y_integrals.txt	exists
099gap180.000x+00.00y+00.00_i1X_integrals.txt	exists
100gap180.000x+00.00y+00.00_i2X_integrals.txt	exists
097gap180.000x+00.00y+00.00_i1Y_integrals.txt	exists

098gap180.000x+00.00y+00.00_i2Y_integrals.txt	exists

Sub folder: Fiducialization `exists`

LCLS2HE SXU 023 Fiducial Report.docx	exists

Sub folder: Gap Measurements `exists`

Sub folder: Gap Measurements\Touch Probe `exists`

003gap010.000taper-0.100.pdf	exists
003gap010.000taper-0.100.txt	exists
004gap010.000taper+0.000.pdf	exists
004gap010.000taper+0.000.txt	exists
001gap010.000taper+0.100.pdf	exists
001gap010.000taper+0.100.txt	exists
002gap010.000taper+0.300.pdf	exists
002gap010.000taper+0.300.txt	exists

Sub folder: Capacitive Sensors `exists`

gap_dat_ru1.dat	exists

Sub folder: Controls Data `exists`

he_sxu_023_parameters.txt	exists
he_sxu_023_k_vs_gap_spline.dat	exists
he_sxu_023_phase_match_enter_vs_gap_spline.dat	exists
he_sxu_023_phase_match_exit_vs_gap_spline.dat	exists
he_sxu_023_i1xvsgap_spline.dat	exists
he_sxu_023_i1yvsgap_spline.dat	exists
he_sxu_023_i2xvsgap_spline.dat	exists
he_sxu_023_i2yvsgap_spline.dat	exists

Summary of findings

Finding	**Solution**

Approval and Assignment by Heinz-Dieter Nuhn

Data Storage Checked:	Y	
Magnet Accepted:	Y	
Assigned Location:	HE_SXU_023	

Heinz-Dieter Nuhn	Heinz-Dieter Nuhn	August 13, 2024
(Signature)	(Name)	(Date)