HXMA BL Operation Notes:

X-ray Beam Vertical Position Stability Under Mirror-Mono-Mirror mode with Si(220)/Pt Configuration

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1. Introduction

It was reported by a HXMA user group in the cycle 10 of 2009 that the X-ray beam vertical position drifted during their experiment even after storage ring injection finished for a relative long time. This issue was investigated at XAFS endstation at HXMA BL. The testing was focused on the integrated effect on the X-ray beam vertical position from the power loading variation on the BL optics, e.g., mirror and mono crystals. Data and parameters were recorded regarding the beam position, the storage ring current (I_{ring}) , and the voltage output from the I0 ion chamber (15 cm in length between its conducting plates). The last two sets of parameters are closely correlated to the power loading at BL optics.

2. Experimental

The JJ X-ray slits was used in this testing to determine the X-ray beam position. The center of the slits vertical opening (slits opening: $1^{(v)} \times 10^{H}$ mm^2) was scanned repeatedly in 50 μm resolution when storage ring current decayed from 218 to 158 mA. Before each scan the monochromator 2nd crystal was fully tuned, and the voltage output from the I0 ion chamber (slits opening: $10^{(v)} \times 10^{H}$ mm^2 when data was recorded) and the storage ring current were recorded right after the scan. No monochromator in-vacuum motors (neither Z2, Y2, θ_2, nor χ_2) was moved during the experiment, except the piezo at mono 2nd crystal $\theta_2$mechanism for the fully tune purpose. Therefore any effect in beam vertical position fluctuation is attributed the contribution from the power loading variation. The testing condition details are summarized in Table 1.

Table 1. Summary of experimental detail

Items	Operation status	
Experiment date	Dec 17, 2009	
Operator	Weifeng Chen	
HXMA Wiggler	1.9 T	
Storage operation mode	250 mA	
Graphite filter(s)	Out of the beam path	
Primary slits	$1^{(v)} \times 8^{(H)}$ mm^2	
Mirror	Collimating	Pt stripe (pre-mono)
	Toroidal	Pt stripe (post-mono)
Mono	Crystal	Si(220)
	Energy	10 KeV, fixed
Detector	I0 straight ion chamber filled with 100% N_2 , gain= 1×10^6	
Beam pipe setup	Between WB pipe end and JJ slits, filled with 100% He	
Experiment time scope	I_{ring} from 218 to 158.8 (mA)	
Detune	Rate	Fully tune
	Energy position	10 KeV,
	Detector	Photo diode at WB pipe end

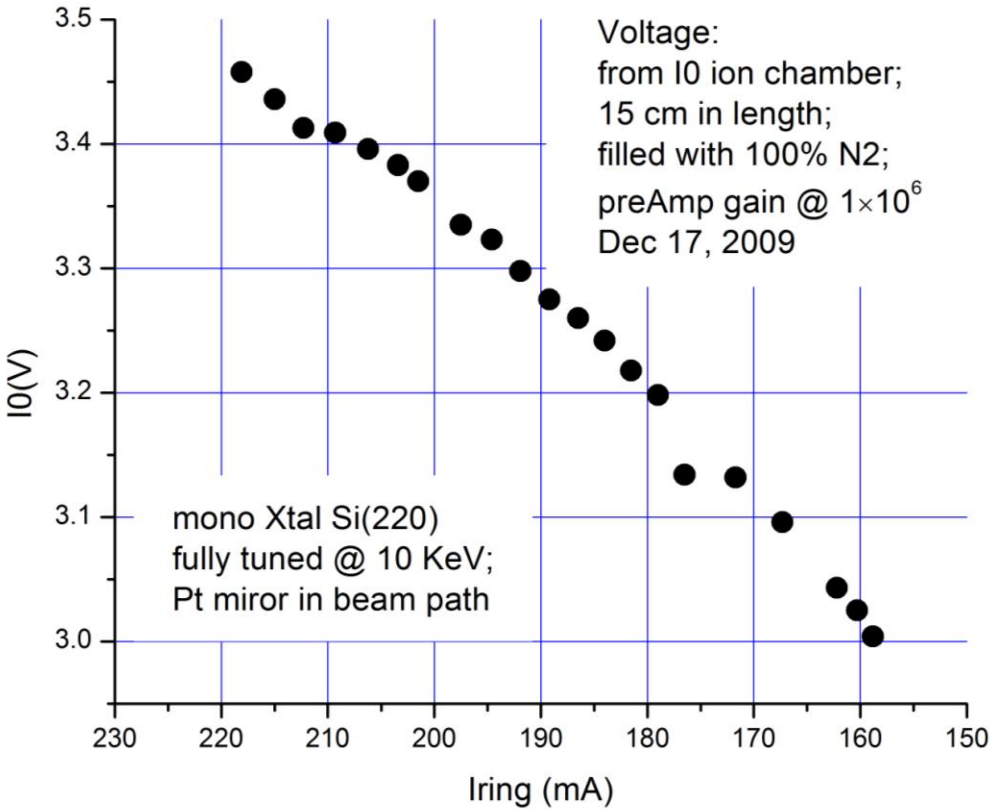

Figure 1. The. The decreasing in measured voltage output from the I0 ion chamber detector versus the storage ring current I_{ring} decay.

Figure 1 shows the in-step decreasing in X-ray flux (the voltage output from I0 ion chamber recorded herein) with the storage ring current decay. The correlation between the two operation parameters is clearly resolved. With a decay scope of 60 mA of I_{ring}, the I0 output varied up to 15% at 10 KeV energy. Of course the variation rate in flux is operation condition related, and is expected to be changed when the mono was operated at different energy position, and different mono crystal in the beam path.

It is realized that to accurately determine the X-ray beam hot spot, beam profile 2D micro-mapping is required, like the case shown in Figure 2. Although its result is more accurate, considering the time required, practically the mapping scheme is difficult to catch the subtle and instant effect from the thermal effect. One the other hand scanning the slits center is more efficient with and tolerable error for this testing, therefore this scheme was adopted in this testing.

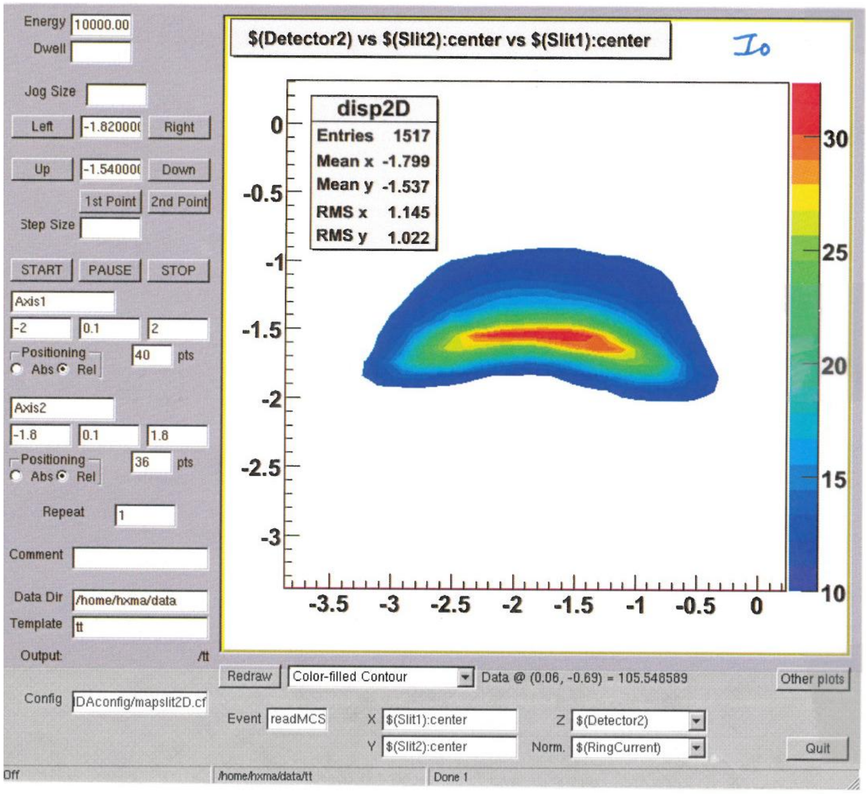

Figure 2. X-ray beam spot at XAFS focus point delivered by mirror-mono-mirror mode with Si(220)/Pt configuration when mono was running at 10 KeV energy. Mono 2nd crystal is 50% detuned (positive side). X-ray was recorded by I0 ion chamber (filled with 100% N2) when scanning the JJ X-ray slits opening center vertically and horizontally with slits opening 100×100 μm^2. Gain at preAmp is 5×10^7. No beam pipe setup between the JJ X-ray slits and WB pipe end. Imaging time is 56 minutes. Data was collected on February 11, 2009.

Figure 3 displays the measured vertical cross sections of the X-ray beam profile, which were obtained by scanning the JJ X-ray slits vertical opening center at different storage ring current scenario. Because of the "happy face" type of beam spot profile (Figure 2), slight asymmetry in beam cross section is resolved. This phenomenon makes the way to determine the beam center not unique, e.g., maximum I0 output point, middle point of the FWHM, or middle point of the two inflection points on the increasing and decreasing sides of the cross section curve. But in this testing, the beam center consonantly refers **herein** to the measured maximum flux point along the beam profile cross section (Table 1). By this scheme the determined beam center was directly from the raw data, no data interpolation was involved to avoid the possible error introduced by mathematical methodology. The determined beam center might not exactly be the hot spot of the beam profile (Figure 2). But since the scheme used is consistent throughout the data interpretation, thus the error carried by the determined position data is believed to be a systematic error type (in vertical position), therefore will have very limited impact to the variation trend of the beam vertical position variation.

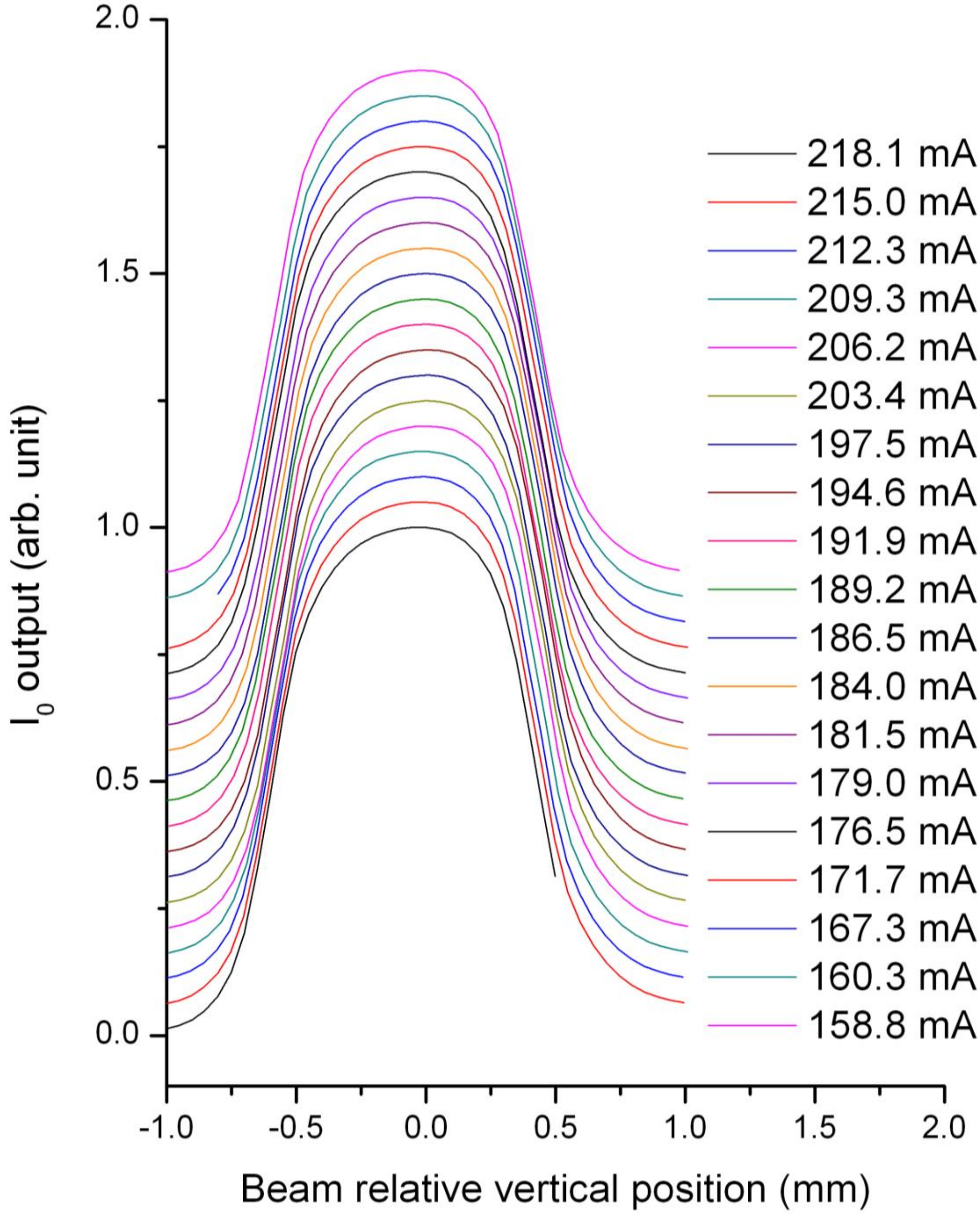

Figure 3. X-ray beam vertical profile recorded by scanning the JJ X-ray slits vertical opening center versus the X-ray beam. Notice that the origin in the X axis coordinate has been moved to the averaged beam center position (Table 1) for the convenience of comparison.

Table 1. The estimated X-ray beam vertical position

No.	Time	I_{ring} (mA)	I0 output (V)	Absolute position (μm)	Relative position (μm)
1	2:24	218.1	3.458	648.41	-2.28
2	2:38	215	3.436	646.13	-4.56
3	2:51	212.3	3.413	642.61	-8.07
4	3:05	209.3	3.409	660.07	9.39
5	3:20	206.2	3.396	660.07	9.39
6	3:34	203.4	3.383	651.08	0.39
7	4:04	201.5	3.335	660.07	9.39
8	4:19	197.5	3.323	651.08	0.39
9	4:34	194.6	3.298	660.07	9.39
10	4:49	191.9	3.275	642.09	-8.60
11	5:04	189.2	3.26	651.08	0.39
12	5:19	186.5	3.242	660.07	9.39
13	5:34	184	3.218	642.09	-8.60
14	5:49	181.5	3.198	660.07	9.39
15	6:04	179	3.134	651.08	0.39
16	6:35	176.5	3.132	660.07	9.39
17	7:05	171.7	3.096	648.92	-1.77
18	7:53	167.3	3.025	640.29	-10.40
19	8:03	162.2	3.004	627.70	-22.99
average	-	-	-	650.69	1.05

a. The absolute position refers to vertical positions where the measured maximum I0 output is reached;
b. The relative position was obtained by defining the averaged absolute position, namely 650.69 μm, as vertical zero position for convenience of comparison.

3. Results and discussion

Figure 4 summarizes the experimental data. There are two data sets are included. The 1st data set (solid circle, Fig. 4) shows the correlation between the beam vertical position (left Y axis) and storage ring current (bottom X axis). The 2nd data set (crossed open circle, Fig. 3) shows the correlation between the beam vertical position (right Y axis) and the detected X-ray signal by the I0 ion chamber (top X axis). Here the scale is identical for the left and right Y axis. Based on the data included in Figure 4, following observation can be made regarding the beam vertical position at HXMA sOE when the monochromatar 2nd crystal is tuned to an identical detune rate (fully tune in this testing case):

a. The correlations revealed by the two data sets, namely, beam vertical position versus storage ring current and versus the flux seen at sOE, respectively, are consistent to each other. This consistency is expected, which reveals that under the accuracy level of voltage readout from the I0 ion chamber detector, the I0 ion chamber at sOE and the optics [mirrors (×2) and mono crystals(×2)] in pOE at HXMA all response properly to the incident X-ray from the wiggler source, either white beam or monochromator beam;

b. Revealed by the current detecting scheme, the beam vertical position doesn't possess any systematic variation trend versus time, storage ring current, and flux detected; therefore it is independent to the BL and storage operation parameters, including flux detected at XAFS endstation at HXMA sOE, the power loading at monochromator crystal and other optics in the beam path, and Iring;
c. The estimated beam positions are distributed within a range up to ~20 μm. This dispersive range is within ~half of the scan spatial resolution (scan step = 50 μm). Therefore the beam vertical motion is not detectable under the current detecting scheme;
d. Previous works indicate that the reproducibility in position when scanning the JJ X-ray center is ~ 20 μm. Thus the recorded beam position changing might be partially the consequence of motor control issue, e.g. backlash, rather than BL optics related; and the real beam vertical position changing might be smaller than the observed data.

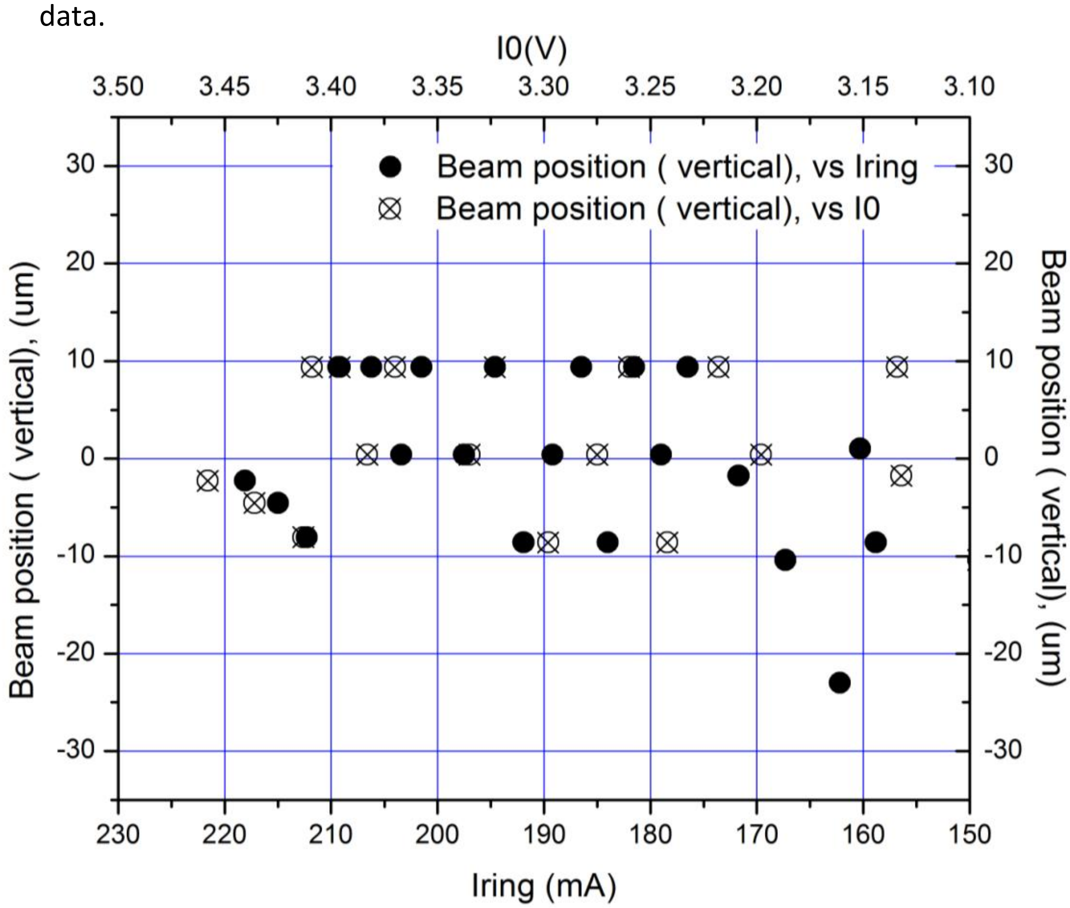

Figure 3. The x-ray beam vertical position versus the storage ring current Iring (solid circle), and versus the x-ray flux in terms of I0 ion chamber voltage output (crossed open circle). Notice that for

observation convenience measured beam vertical positions have been drifted relative to its averaged position.

4. Conclusion

The beam vertical position is fixed at HXMA sOE if the monochromator 2nd crystal is tuned to a constant rate under the current detecting scheme. Investigation can be further performed with higher scanning spatial resolution and with driving motors backlash calibrated at JJ X-ray slits, or by using more accurate scanning stage.