## HXMA BL Operation Notes:

### X-ray Beam Vertical Position Stability -Mono 2nd Crystal Tuning and Detuning Effect

Ning Chen, Weifeng Chen

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### 1. Introduction

At HXMA, there are multiple cases in which the beam was out of its proper position vertically, and/or the flux of the X-ray photon was fluctuated. It has been indicated that in lot of scenarios the major effect was from the improper detuning the $\theta 2$ mechanism of the 2nd crystal of the monochromator.

As part of continuing effort to evaluate the beam stability at HXMA, the effect from the tuning and detuning of the $\theta 2$ mechanism has been investigated. In order to reduce the impact from the I0 decay and to reduce the number of the variables involved in the process, the whole experiment was performed as quickly as possible. The testing was finished as a whole within 74 minutes with a ring current decay of 13.3 mA. Also during the data interpretation the presented I0 data has been normalized to 250 mA of full power of the storage ring operation for the convenience of comparison and data interpretation.

### 2. Experimental

The experiment detail has been summarized in Table 1. The center of the vertical opening of the JJ X-ray slits was scanned vertically under different detune rate (Table 2). During the experiment there is no motorized motion for any optics in HXMA pOE.

Table 1. Summary of experimental detail

| BL components | Operation status | |
|---|---|---|
| Experiment date | Jan 9, 2010 | |
| Operator | Weifeng Chen, Ning Chen | |
| HXMA Wiggler | 1.9 T | |
| Storage operation mode | 250 mA | |
| Graphite filter(s) | Out of 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 | Cu K edge |
| Detector | Straight ion chamber filled with 100% $N_2$ for I0 | |
| Beam pipe setup | Between WB pipe end and JJ slits, He filled | |
| JJ slits | Opening | $1^{(v)} \times 3^{(H)}$ mm$^2$ |
| | Scan mode | Single scan(backlash calibrated) |
| Experiment scope | Iring from 167.6 to 154.3 mA, $\Delta$=13.3 mA<br>Time: 74 minutes in total | |
| Detune | Rate | 0 to 80 % |
| | Energy position | at Cu K edge |
| | Detector | Photo diode at WB pipe end |

Table 2. Experimental condition and experimental data

| Scan ID | Detune Rate (%) | Piezo setup (arb. Unit) | Iring (mA) | Beam center ( μm) | I0 output (V) | |
|---|---|---|---|---|---|---|
| | | | | | Raw data | Normalized[a] |
| 1 | 0 | N/A | 167.6 | 333.4 | 1.945 | 2.901 |
| 2 | 3 | 239.9 | 166 | 300.3 | 1.868 | 2.813 |
| 3 | 5 | 300.1 | 164.8 | 294.4 | 1.823 | 2.766 |
| 4 | 10 | 432 | 163.7 | 237.5 | 1.714 | 2.618 |
| 5 | 15 | 553.7 | 162.6 | 199.9 | 1.616 | 2.485 |
| 6 | 20 | 674.2 | 161.6 | 163.8 | 1.514 | 2.342 |
| 7 | 30 | 897.4 | 160.4 | 80.8 | 1.317 | 2.053 |
| 8 | 45 | 1205.7 | 158.9 | -20.5 | 1.025 | 1.613 |
| 9 | 50 | 1306.5 | 157.8 | -35.8 | 0.933 | 1.478 |
| 10 | 60 | 1495.2 | 156.5 | -122.5 | 0.735 | 1.174 |
| 11 | 70 | 1698.2 | 155.4 | -176.0 | 0.538 | 0.866 |
| 12 | 80 | 1839.9 | 154.3 | -266.1 | 0.375 | 0.608 |
| Δ | - | - | 7.9 (%)[b] | 599.5 μm[c] | 81.0 (%)[b] | 79.0 (%)[b] |

a. I0 data has been normalized to 250 mA of full power of the storage ring operation;
b. % deviation of the data at 80% detune versus the data at fully tune;
c. Absolute difference between fully tune and 80% detune

Figure 1 shows the response from the piezo to the progressively changed requests of detuning. The trend in the piezo setup is smooth, no apparent glitch in trend resolved; indicating that piezo instantly and properly reacts to its requests.

Figure 2 provides the voltage readout from the I0 ion chamber versus the decay in the storage ring current during the experiment, showing a "correlation" between the two variables. But since the voltage readout presented herein (Table 2) has been normalized to 250 mA of the storage ring current, there should be no correlation at all between the two after the normalization. Therefore the I0 decreasing shown (Fig.2) is "solely" from the effect beyond the ring current decay, and which is essentially from the detuning of the mono 2nd crystal targeted for this testing.

Figure 3 displays the vertical cross section of the X-ray beam profile when the θ2 mechanism of the monochromator 2nd crystal is fully tuned to the 1st crystal (black trace, rightmost curve) to 80% of detune (yellow trace, leftmost curve). In the figure, the X axis is the relative position of the JJ X-ray vertical center, the 0 position is arbitrary, defined by the current slits calibration; while the Y axis is the voltage output from the I0 ion chamber, which has been normalized to unit for the convenience of comparison. A total of 600 μm vertical movement of the beam center has been detected. Furthermore it is observable that the cross section of the beam profile is slightly asymmetric, which has been discussed elsewhere (see *HXMA BL Operation Notes: X-ray Beam Vertical Position Stability Under Mirror-Mono-Mirror mode with Si(220)/Pt Configuration* for some detail).

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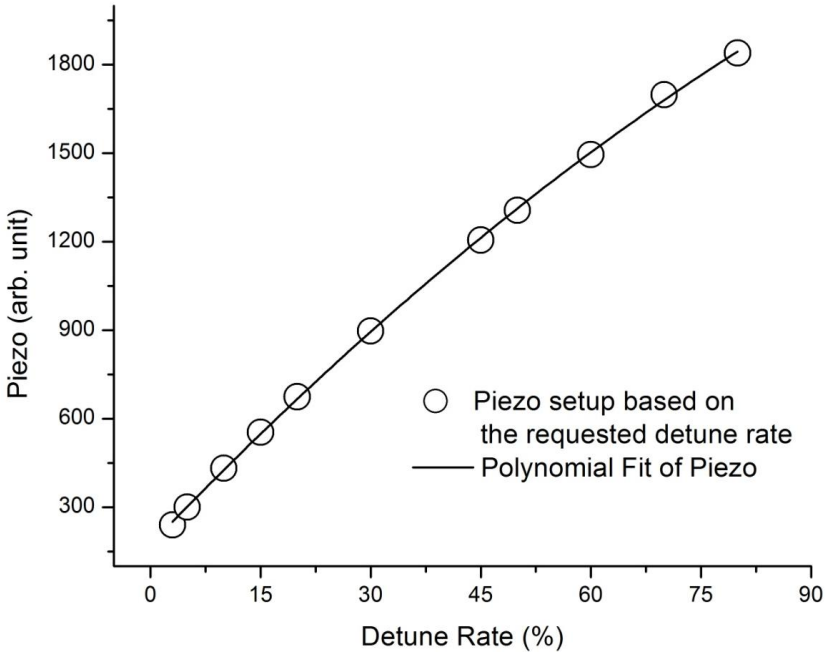


Figure 1. The piezo setup based on different requested detune rates at θ2 mechanism of the mono 2nd crystal, indicating that piezo responses properly to its setup request.

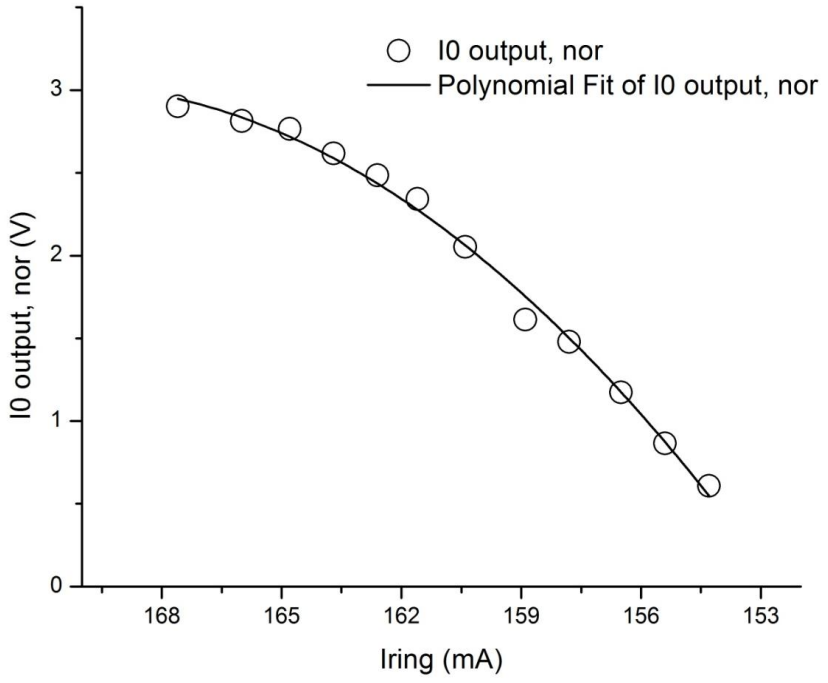


Figure 2. The voltage readout from the I0 ion chamber versus the Iring. Here the voltage readout has been normalized to 250 mA storage ring current to remove the effect from Iring decay. Therefore the I0 decreasing presented here is "solely" from the effect of the detuning for the mono 2nd crystal.

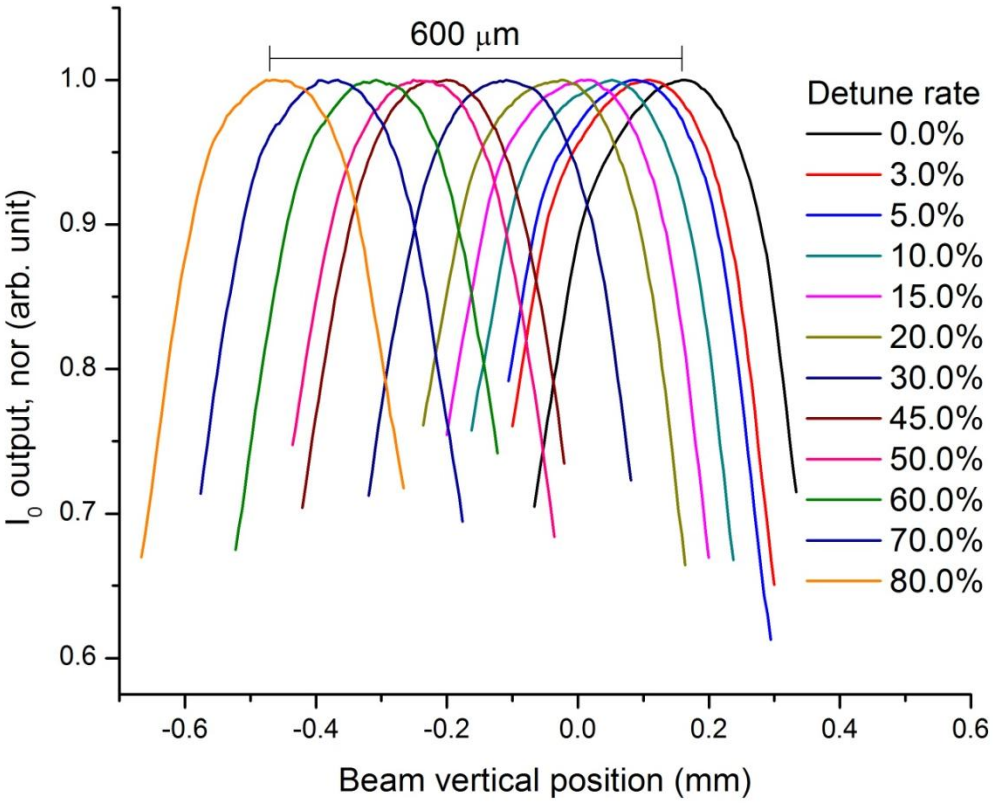


Figure 3. The vertical cross section of the X-ray beam profile at different detune rate for the θ2 mechanism of the monochromator 2nd crystal. Here the X axis is the relative position of the JJ X-ray vertical center, while the Y axis is the voltage output from the I0 ion chamber. The I0 voltage has been normalized to unit for the convenience of comparison.

### 3. Results and discussion

Figure 4 presents two data sets to disclose two different correlation relations, both detune related. The 1st correlation (open circles, in blue) is between the detune rate (bottom X axis) and beam vertical position (left Y axis). An almost linear correlation is revealed with **a** slope of 7.3 μm [ Δ (μm)/ detune (1%) ]. This means that if a 25 μm aperture or collimator used in an experiment, 3% of off-tune will make the beam totally lost. And it is expected that if there are multiple apertures and/or slits arranged for an experiment, the sensitivity for the setup to the off-tune will be much more serious.

Overlaid with the 1st data sets, the 2nd correlation (crossed open circles, in red) is shown between the detune rate (top X axis, the top and bottom X axis are identical) and the voltage readout form I0 ion chamber detector (right Y axis). Here the voltage readout has been normalized to the 250 mA of ring current to remove the effect from the storage ring Iring decay. Again an almost linear correlation is revealed. But the impact from detune to the I0 is much gentle with a slope of **2.88×10$^{-2}$** [Δ (V)/detune (1%)]. Therefore at a fixed mono energy position if I0 changing is obviously visible, the mono 2nd crystal tune and detune must change extensively, in another words, X-ray beam is vertically drifted. On the other hand, the so-called "gentle" response from I0 to detune is true only when the JJ X-ray slits is widely opened. When the opening of the slits is smaller, the sensitivity of I0 responding to detune is expected to be modified. Following experiment will be performed to verify this.

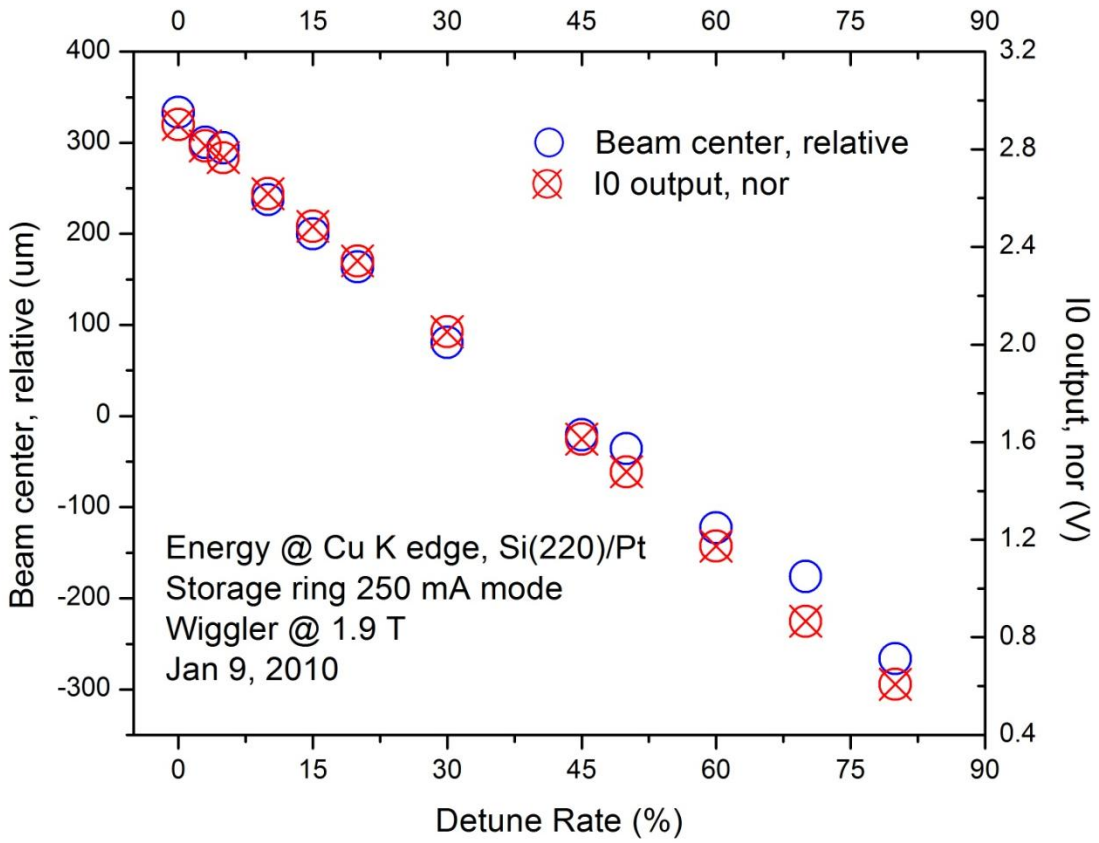


Figure 4. Two correlation relations herein related to the detune rate of the θ2 mechanism of the mono 2nd crystal. The 1st correlation is between the detune rate and the beam vertical. The 2nd correlation is between the detune rate and the voltage readout form I0 ion chamber detector. Here the voltage readout has been normalized to 250 mA ring current to remove the effect from the storage ring current decay. Both slits and ion chamber are located at XAFS endstation of HXMA sOE.

Similar to Figure 4, Figure 5 overlays two data sets to disclose two different, but related correlation relations. Here piezo setup has replaced the required detune rate. In the Figure 5, the top and bottom X axes are identical. But left Y is for the beam vertical position (open circles, in blue), and the right Y is for the I0 output. And the I0 data has been normalized to 250 mA storage ring current. Here the correlation of piezo response to the beam vertical position and the I0 readout are revealed again both liner with slopes of **3.4×10$^{-1}$** μm [ Δ (μm)/ piezo (arb. unit)] and **1.0×10$^{-3}$ V** [Δ (V)/ piezo (arb. unit)], respectively. The correlations revealed in Figure 5 are essentially same as those presented by Figure 4 under the condition that the piezo can properly response to the detune requests, which has been confirmed by this experiment (see Fig. 1).

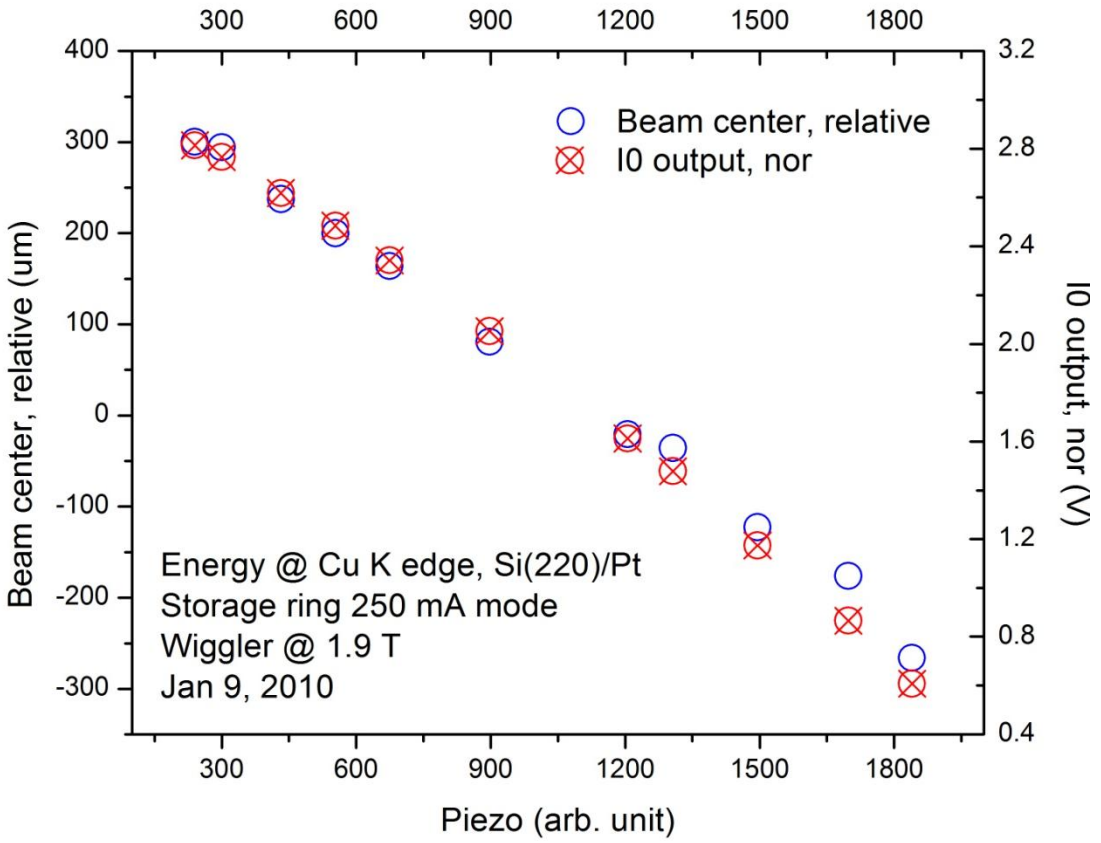


Figure 5. Two correlation relations herein related to the piezo response. The 1st correlation is between the piezo setup and beam vertical position (left Y/bottom X). The 2nd correlation is between the piezo setup and the voltage readout form I0 ion chamber detector (right Y/top X). Here the voltage readout has been normalized to 250 mA ring current, and the top and bottom X are identical.

## 4. Conclusion

The detune control through the piezo to the θ2 mechanism of the mono 2nd crystal has been indicated working properly. The correlations between detune (or piezo setup) and the beam vertical position and between detune (or piezo setup) and I0 output have been revealed to be linear. The slopes of the response of beam vertical position and the I0 output to the detune (or piezo setup) has been estimated for the operation of mirror-mono-mirror mode with Si(220)/Pt configuration. Since the response of the I0 readout is very gentle to the detune (Figures 4 & 5), whenever its changing is obvious, detune is recommended to be performed as soon as possible to make sure the alignment of X-ray beam versus the components of the experiment setup, e.g., slits, aperture, collimator, detector, and sample.