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Beamline Alignment for 2561-2 and 2562-1 Beam Service Cycles

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Beamline 8: X-ray Absorption Spectroscopy

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1. Introduction

After a shutdown of the SPS synchrotron machine and re-operation for user service, there may be some changes of the electron beam orbit, resulting in the change of the X-ray source positions to where the fixed aperture (LCV) and the optics (collimating mirror and double crystal monochromator) of the beamline 8 (BL8) are needed to be aligned. Therefore, the best alignment is desired to obtain the best performance of the beamline in terms of photon flux and photon energy resolution.

For the beam service of 2561-1 and 2561-2 cycles: October-December 2018 and January-June 2019, the alignment of the beamline BL8 was carried out during September 11-19, 2018. This report describes the principle and procedure of the BL8 alignment.

2. Principle of the beamline alignment

There is only one fixed aperture in the front end of the beamline, namely, the LCV duct. Its inner aperture dimension is 7 mm (H) x 4 mm (V). The center of the aperture must be aligned with the center of the white beam of the BM8. The first wire-scan XBPM is an essential tool to check the alignment of the LCV. The beam center is defined as the position whose photon intensity is highest. The next step is to align the center of the collimating mirror (CM) to the beam center, in which the first and the second wire-scan XBPMs are used. The setting of V1 and V2 entrance slit of the CM must be determined so that the beamline personnel know how to adjust them to irradiate 40% to 100% of the CM meridional surface. The 40% to 60% setting is preferred for XANES measurements requiring better photon energy resolution. EXAFS measurements can use the beam up to 80% without broadening of the EXAFS oscillation. Note that the 80% beam matches the active length (480 mm) of the CM set at 0.5 mrad incident angle. The alignment of the double crystal monochromator (DCM) is done at the 40% beam whose beam height is about 1 mm seen at the entrance port of the DCM. This is equivalent to the use of DCM slit during the commissioning work in October 2016 (W. Klysubun et al., BL8 Installation 2016 Log Book). The best of DCM alignment is obtained when the incoming beam is exactly at the DCM rotation center. This ensures the fixed exit condition.

3. Alignment of the LCV aperture

3.1 Scan W1 to check the white beam profile downstream the LCV aperture.

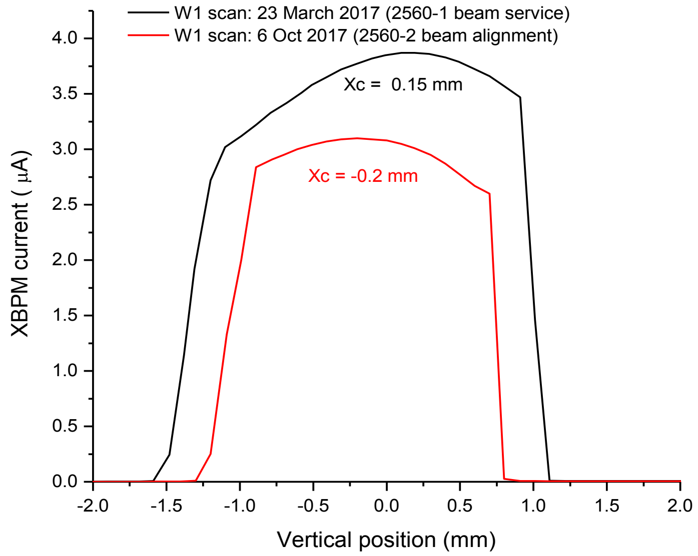

Fig. 1 W1 scans showing the vertical beam center.

In this user service cycle (2560-2), the vertical beam center was shifted by -0.35 mm relative to that of the previous cycle (2560-1). We decided not to change the position of the LCV as it was only 200 microns of the vertical shift measured by the W1 scan downstream and that the central good portion of the beam has passed the LCV. Note that the V slit was 80% in both scans of W1.

3.2 It is recommended to adjust the LCV when the vertical shift is larger than ±0.5 mm.

4. Alignment of the collimating mirror

4.1 Move the CM downward by 6 mm so that it does not intercept the beam. Note that , from the previous cycle (2560-1), the pitch angle of the DCM has been 5 mrad and the vertical center of the CM has been -0.25 mm.

4.2 Scan W2 to check the white beam vertical position. Figure 2 shows that, in this cycle (2560-2), the beam vertical center is at 3.35 mm or shifted by -0.34 mm relative to that of 2560-1.

4.3 Move CM down by 0.35 mm to intercept the beam. Note that the CM positions (in mm) are

$$z1 = -1.95087$$

$$z2 = 0.75274$$

$$z3 = 0.75277$$

$$x1 = -0.00088$$

$$x2 = 0.00101$$

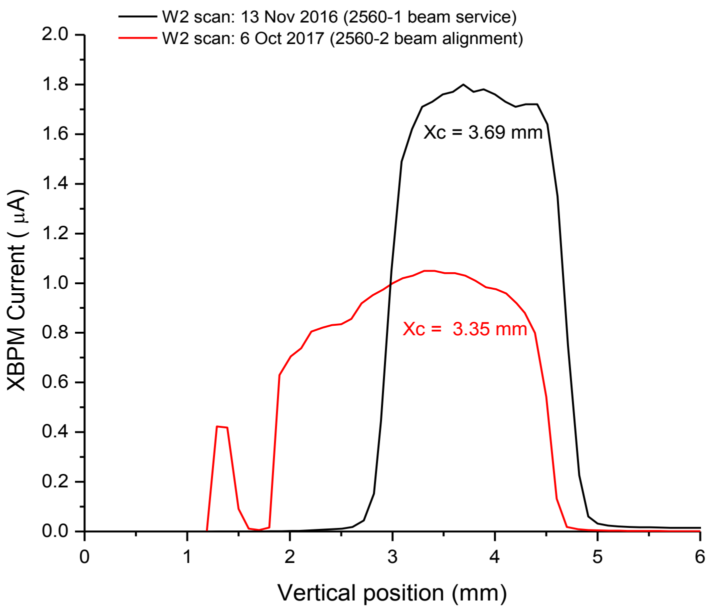

Fig. 2 W2 scans showing the vertical beam center, CM out off the beam axis.

4.4 Adjust the V1/V2 slit so that both of them match the length of the mirror. This is done by opening them wide enough to see scattering effect from the edges of the mirror, then reducing V1 and V2 to cut off the scattered portions (B and D) and the direct beam (A).

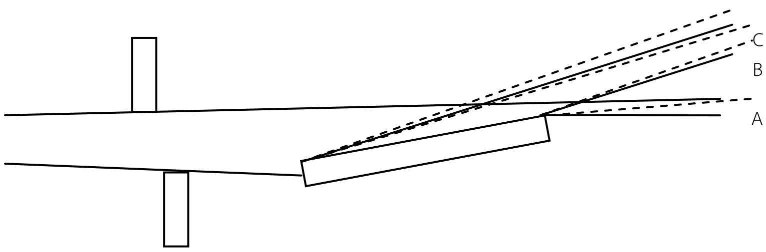

Fig. 3 Schematic view of scattered beam (dashed lines) due to the edges of the mirror.

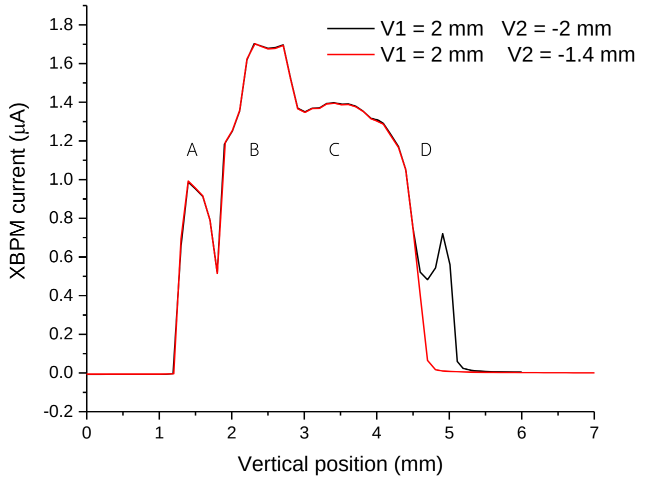

Fig. 4 W2 scans showing the desired position of V2 (-1.4 mm).

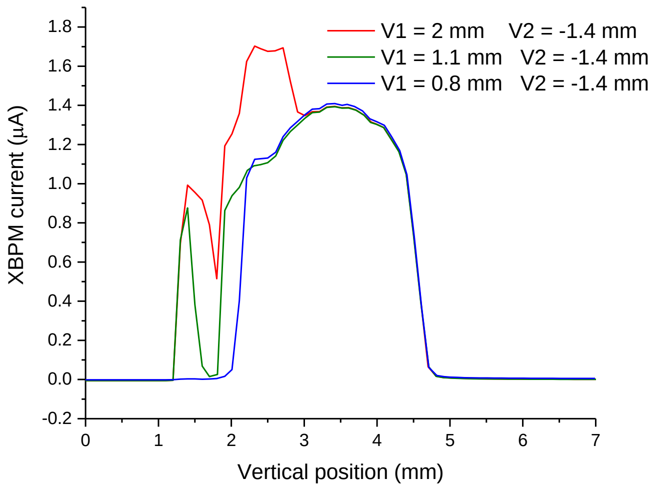

Fig. 5 W2 scans showing the desired position of V1 (0.8 mm).

4.5 Figure 5 shows the center of the reflected beam at 3.4 mm.

4.6 Determine the position of V1 (V2) coresponding to the reflected beam center by adjusting it to cut all of the reflected beam below (above) 3.4 mm.

4.7 Note that the 100% CM results in the vertical size of 2.4 mm of the colimated beam downstream the CM, smaller than the calcuated value (3.0 mm) in the case of 600 mm-long CM at 5 mrad incidence. This may indicate the V1 of 0.8 mm is over set.

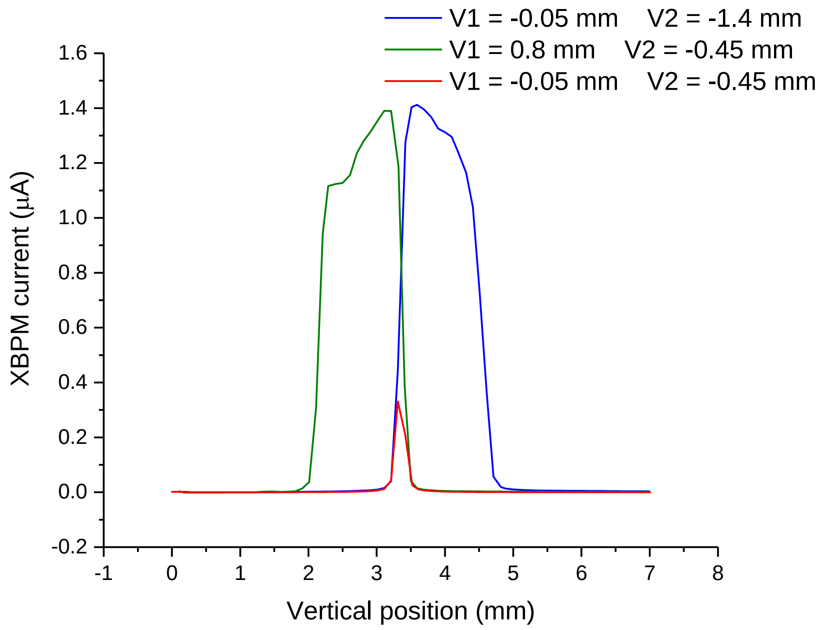

Fig. 6 W2 scans showing the half-cut positions of V1 and V2 (-0.05 mm and -0.45 mm).

4.8 We define the range of V1 from -0.05 mm to 0.8 mm as the opening of the upper half of the white beam upstream the CM and the range of V2 from -0.45 mm to -1.4 mm as the opening of the lower half. Consequently, the setting of V1 and V2 can be calculated for percentages of irradiation on the CM mirror.

Table 1 Setting of V1 and V2 for XANES and EXAFS measurements.

% CM	V1 (mm)	V2 (mm)
100	0.80	-1.40
90	0.72	-1.31
80	0.63	-1.21
70	0.55	-1.12
60	0.46	-1.02
50	0.38	-0.93
40	0.29	-0.83
30	0.21	-0.74
20	0.12	-0.64
10	0.04	-0.55

5. Alignment of the double crystal monochromator

5.1 Paste a burn paper at the entrance hole of the DCM. The cross hair lines drawn on the paper must be exactly aligned with the reference line of the inner wall at the entrance hole.

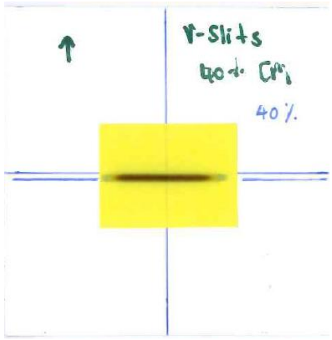

Fig. 7 Beam footprint on a burn paper. The upper horizontal line indicates the reference of the inner wall at the DCM entrance hole.

5.2 The collimated beam is -0.5 mm from the reference. From the previous cycle (2560-1), we have found that the rotation point of the DCM is 0.95 mm above this reference line, therefore the beam shown in Fig. 7 is lower than the rotation point by 1.45 mm. The beam is horizontally symmetric, thus the DCM does not need any horizontal alignment.

5.3 Adjust the four legs of DCM to lower the DCM chamber by 1.5 mm. Make a mark on each leg and measure the adjustment with a ruler. Check the resulting beam position on a burn paper.

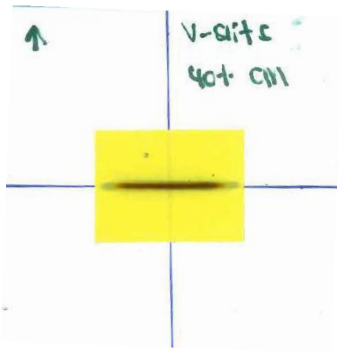

Fig. 8 Beam footprint on a burn paper after 1.5 mm downward adjustment. The upper horizontal line indicates the reference of the inner wall at the DCM entrance hole.

5.4 Paste a burn paper on a dummy installed as the 1st crystal. Observe the beam position at about -17° and 17° of the motor rotation angle.

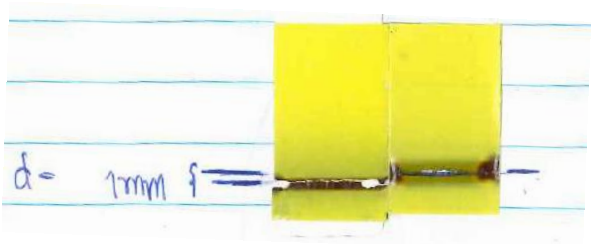

Fig. 9 Beam footprints on the dummy at -17.0126° (left) and 16.2945° (right) of the motor rotation angle.

The difference of the beam position indicates the beam is not yet on the rotation center of the 1st crystal. When the rotation center is lower (higher) than the beam, the -17° beam footprint is lower (higher) than the 17° beam footprint. This means the adjustment in the step 2 is incorrect.

5.5 Adjust the four legs of the DCM chamber upward by 0.6 mm. Observe the beam positions on burn papers.

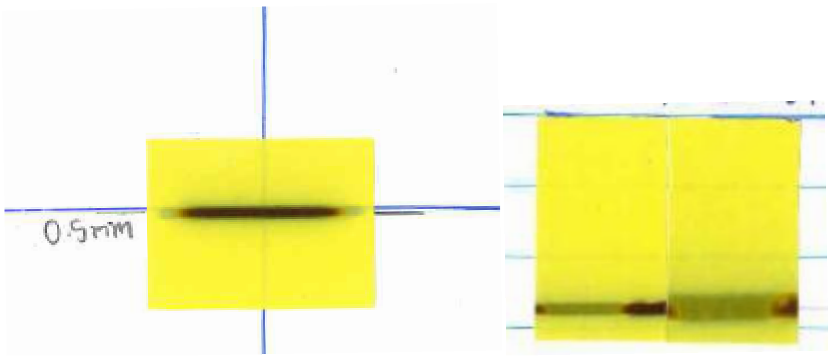

Fig. 10 Beam footprints at the DCM entrance and on the dummy at -17.0126° (left) and 16.2945° (right). The beams of both angles are on the DCM rotation center.

In this case, the beam is on the rotation center and reference line is 0.5 mm above it.

5.6 Three new reference markers are made in the DCM. Mark A represents the rotation center of the 1st crystal while Marks B and C represent the beam vertical center in this cycle. Mark A is higher than B and C by 2.675 mm and 200 mm behind. Thus, the reflected angle of the beam is given by $\tan^{-1}(2.675/200) = 13.4$ mrad. Note that the theoretical reflected angle is 10 mrad.

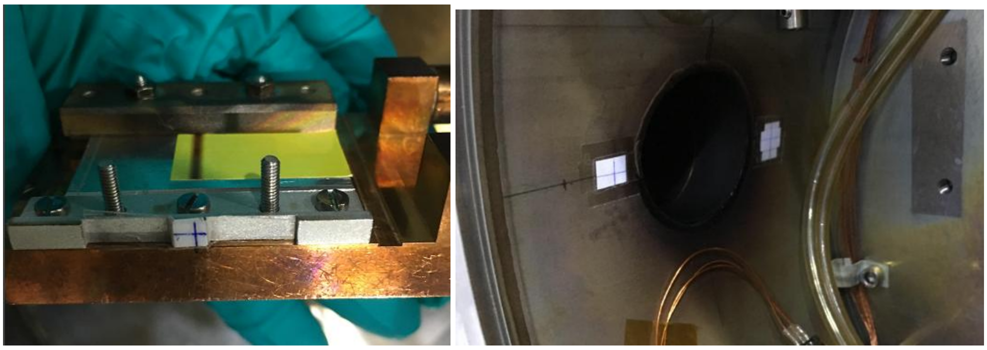

Fig. 11 Three new reference markers (A on the rotation center; B and C on the beam center) for the ease of DCM alignment in the future.

5.7 Install InSb(111) crystals, maximize I_0 current signal, paste a burn paper at the exit hole inside the DCM. The beam footprint is 20 mm (H) x 1 mm (V) and center at -0.2 mm (H), -0.5 mm (V) with respect to the reference line of the exit hole.

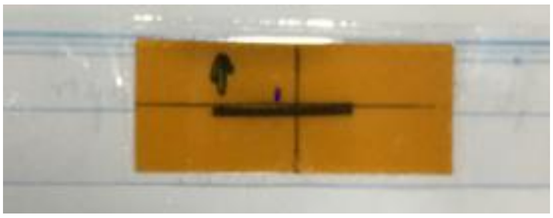

Fig. 12 Beam footprint at the exit inside the DCM.

6. Conclusion and outlook

We successfully aligned the CM and DCM to obtain the collimation and fixed exit conditions. This work was complete in 32 hours with two working teams covering the day and night shifts. The beamline is now ready for the user service in the 2560-2 cycle.

Acknowledgements

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