

# Rowland Circle Geometry based X-ray Spectrometer Alignment Guide

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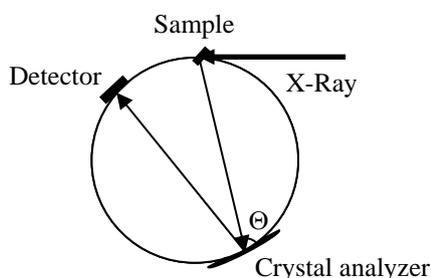


Figure 1, Rowland circle geometry based x-ray spectrometer, Rowland circle diameter equal to the radius of bent crystal analyzer

The alignment task is to let crystal analyzer, detector and single x-ray energy (monochromator) to be linked together. Only after spectrometer aligned, it can be used to do all measurement. Fig.1 shows the principle of Rowland circle geometry based x-ray spectrometer.

There is one suggested to use elastic line to align spectrometer. It can work but take long time and much effort, which used to take at least half day to get job done. Fig. 2 describes why it is a hard job. In fig. 2, it shows  $\Theta$ - $\chi$  plane, where  $\Theta$  is analyzer Bragg angle, and  $\chi$  is analyzer tilt angle. In fig.2 (a), after initial laser alignment, due to crystal miscuts and limited goniometer accuracy, detector (rectangle), analyzer (circle) and single x-ray elastic energy (vertical line) are not always aligned at same point. One can imagine how difficult to align these three devices from fig.2.(a) to fig.2.(b). The reason is you need move two devices of these three to make them align together in two dimension plane in **BLINK**.

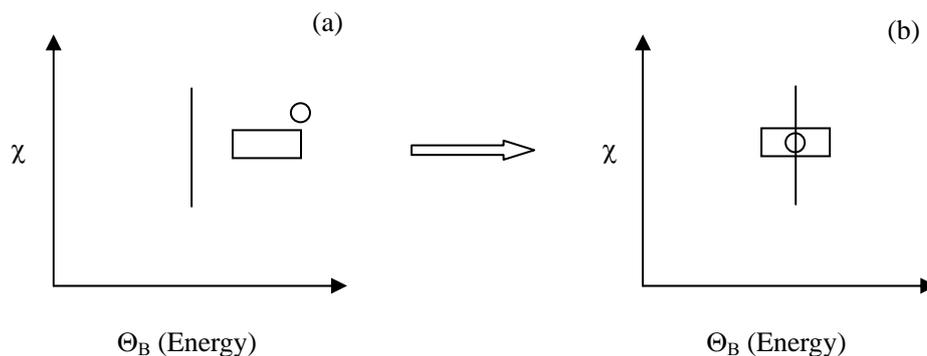


Figure 2, spectrometer alignment with single energy x-ray from elastic scattering

Fortunately, we have another simple way to do this job. The key is to use band energy x-ray in place of single energy x-ray. The fig. 3 shows its principle. Band energy x-ray can be from knowable emission lines which need to cover or to be close to our spectrometer measuring point. From fig. 3(a), we see the detector and analyzer both are in the band energy x-ray field (presented

as the rectangle filled with gray color). The alignment is just move one of two devices (analyzer and detector, usually the analyzer) in  $\Theta$ - $\chi$  plane to align together, since the detector always can get signal if those two aligned in band energy x-ray field. Fig. 3(b) shows the aligned picture. With that method, one can make job done only in 30 minutes.

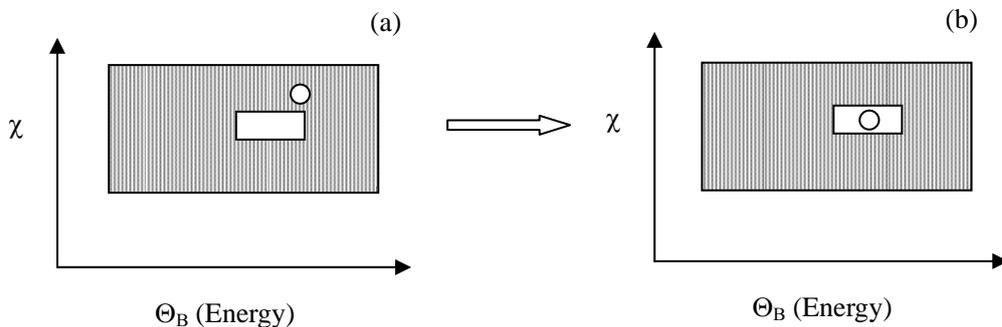


Figure 3, spectrometer alignment with band energy x-ray from knowable emission lines

The following we list all steps for alignment with band energy x-ray:

- 1) Laser initial alignment (necessary for rough alignment before x-ray):
  - (a) Based on energy range for measurement, calculate scattering spot, analyzer and detector position on Rowland circle, and put those three objects on Rowland circle;
  - (b) Use tiny point laser to point on scattering spot, watch reflecting point focused from analyzer, and rotate analyzer to let reflecting point back to scattering spot. Here define Bragg angle as 90 degree;
  - (c) Rotate analyzer to interesting Bragg angle, and set detector at its laser reflecting-focusing point position. Record both of their position parameters as position A;
  - (d) rotate analyzer to another Bragg angle in energy range, and move detector to its new laser reflecting-focusing point position. Record both of their position parameters as position B;
  - (e) Use position A and B parameters to calculate and set analyzer and detector motion parameters to be linked together (linear relationship supposed);
- 2) Band energy x-ray alignment:
  - (a) set up a sample at scattering spot. The sample's emission lines need to cover or to be close to spectrometer measuring energy range. For example, if one want to set spectrometer to measure energy around 6500eV, one can use Mn  $K_{\beta}$  lines (band center at 6490eV) for alignment;
  - (b) Move analyzer and detector to Bragg angle of the sample emission energy(no necessary on peaks);
  - (c) Widely open detector slit to maximum its active entry area;
  - (d) Put on vacuum path or helium path to reducing air absorption if necessary;
  - (e) Turn on x-ray and set monochromator energy above the sample emission edge to create expected emission lines;
  - (f) If there is signal in detector, then fine turn analyzer to maximum, if not, tune analyzer  $\Theta$  or  $\chi$  to get signal and maximized (after laser alignment, real x-ray alignment position should not be far away);
  - (g) Narrow detector slit to reduce background and tune analyzer to maximum signal again;
  - (h) Scan spectrometer energy to find the peak of the emission lines and calibrate spectrometer energy. One also can scan monochromator to calibrate if possible.

For the system with multiple crystals, alignment is similar as above. All crystals first need to be aligned in laser simulation. In X-ray alignment, you need align one time each by shielding all others. But first to align the center crystal following the above steps. After the center crystal aligned in 2)-(f), don't move the whole crystal set  $\Theta$ , just adjust other each crystal by its own titling and rotating angles. After all crystal aligned, you can show all crystals in x-ray before step 2)-(g).

Note, for XAFS mini-spectrometer alignment (such as R=182mm case), if one is only interested in one energy position measurement without scanning spectrometer, then you can reduce some steps above, such as item 1)-(d) and 1)-(e).