Instrumentation for micro-tomography experiments at BL20B2

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Measurement of CONVERSION GAIN for X-ray imaging detector

Measurement of the conversion gain helps us to understand sensitivity of X-ray detectors. In this practice, an X-ray detector which is composed of a beam monitor and a charged coupled device (CCD) camera is used. The incident X-ray beam onto the beam monitor is converted into visible light by a phosphor screen. The visible light image is focused on the CCD camera via relay lenses. The measurement procedure of the conversion gain is as follows.

I. Detection of incident X-ray beam using X-ray detector

You can use image acquisition software "HiPic" to view and analyze X-ray images.

A) Adjust exposure time of the CCD camera so that adequate signals are obtained. Note that long exposure may induce saturation of signals.

B) Adjust aperture size of a slit (TCslit1) using GUI on the X-terminal. In this case, X-ray beam size should be smaller than effective field of view of the X-ray detector.

C) Measure the effective pixel size (μm/pixel) of the X-ray detector used.

II. Measurement of X-ray beam size

A) Select "Rectangle ROI" from a tool bar on HiPic.

B) Indicate the shape of the X-ray beam by ROI. The ROI size should be same as the X-ray beam size.

C) Read out the ROI size in unit of pixel from "ROI interface" window. Then, actual X-ray beam size can be calculated from the ROI size and the effective pixel size.

III. Measurement of X-ray photon flux using ionization chamber.

A) Measure intensity of the incident X-ray beam (I_0). You can read out the digitalized value from ORTEC Counter.

B) In the same manner, measure the dark (background) signal (I_{dark}) without X-ray beam.

C) Calculate real intensity by subtracting I_{dark} from I_0.

D) Convert the digitalized value into voltage. Here, you can use a conversion factor of a V/F converter; 1MHz/10Volts.

E) Convert the voltage into ionization current generated in the ionization chamber. Here, you can use a gain factor of a current amplifier; 10^xVolts/1Ampere. Actual gain factor is displayed in the current amplifier installed on beamline.

F) Calculate X-ray photon flux using a following equation.

$$n(photons/\sec) = \frac{W}{Ee} \cdot \frac{i}{1-\exp(-\mu l)}$$

W: W-value of gas in the ionization chamber. In this case, it is air. W_{air}=33.97eV

E: Incident X-ray energy (eV)

e: Electrical charge; 1.602×10^{-19}(C)

μ: Linear absorption coefficient (cm^{-1}) of air. See Table.

l: Length of electrode in the ionization chamber (cm).

i: Ionization current (A).

Table. 1 Linear absorption coefficient

X-ray energy (keV)	LAC of air (cm^{-1})
15	1.74×10^{-3}
20	8.07×10^{-4}
25	4.95×10^{-4}
30	3.65×10^{-4}

If you have derived the X-ray photon flux, let's calculate the X-ray photon flux per unit area (photons/sec/mm^2) using the X-ray beam size.

IV. Measurement of total amount of signals produced by X-ray detector

A) Acquire an incident X-ray beam image. Remember that signals on the CCD camera should not be saturated. In the case of HiPic, a saturated pixel is represented as red color. Note the exposure time in order to estimate the total amount of signals per 1sec in the following calculation.

B) Acquire a dark image with the same exposure time.

C) Measure the total amount of signals (ADC_{total}) produced by the X-ray detector. Indicate the shape of the X-ray beam using a "rectangle ROI" tool. Here, the ROI size should be larger than the size of X-ray beam to capture all of signals. You can know the total amount of signals using an analytical tool on HiPic. Find "Analysis" located at a menu bar on HiPic and select "Histogram display". Then, you will obtain the total amount of signals (Total count) by pushing "Get histogram" button.

D) In the same manner, measure the total amount of dark signals (ADC_{dark}) at the same ROI position.

E) Calculate the real signal by subtracting ADC_{dark} from ADC_{total}.

F) Convert the real signal calculated above into the total amount of signals per 1sec (*ADC*/sec) by considering the exposure time.

V. Calculation of conversion gain for X-ray detector

A) The conversion gain (*ADC*/photon), which is the amount of signals generated by a single X-ray photon, will be calculated by dividing the total amount of signals per 1sec (*ADC*/sec) by the incident X-ray photon flux (photons/sec).