Correlating photoelectrons ADU counts to incoming X-ray photons numbers and energy

Applicable to direct X-ray detection 'SY' & 'SO' CCD / EMCCD / sCMOS cameras

Background

SOLIS software (or similar control software) will present the data from the camera as digital counts (ADU). Here we discuss the methodology for linking ADU values to the approximate number of incident X-ray photons on the sensor for SO and SY direct high energy detection (HED) cameras,

Initial considerations

There will be a DC offset applied to the baseline of each camera. This offset level will vary for various camera / sensor types, as well as a small variation from camera to camera. This will need to be subtracted from the signal level in order to ensure that only the actual 'useful' signal is being measured. The simplest way to determine this baseline will be to acquire a dark image (or background). This dark / background image can be subsequently subtracted from a signal image to only display the true 'useful' signal ADU count level.

Methodology

1. Convert to photoelectrons

CCD and sCMOS sensors

Photoelectrons generated at the sensor = (Counts – Offset) x Sensitivity

EMCCD sensors

Photoelectrons generated at the sensor = [(Counts – Offset) x Sensitivity] ÷ absolute EM Gain

2. Calculate number of photoelectrons generated as a function of incident X-ray photon energy (see Appendix A)

= Number photoelectrons ÷ number of photons generated at a given Energy

In order to then convert this number of photoelectrons to the number of incoming photons, this value is multiplied by the QE (in %) of the CCD/ EMCCD/ sCMOS sensor at the photon energy of interest.

This QE data is available in the specification sheets for all camera types, which are freely available for download from the Andor website, (www.andor.com).

3. Calculate incident photons number

= Number photoelectrons x %QE

4. Calculate photon energy (E) – if required

Photon Energy = energy (eV) * 1.602×10^{-19} (1eV = 1.602×10^{-19} J)

Energy of incident = Incident photons * Photon Energy

If you require further information or assistance, please contact your local Andor Product Support representatives [1].

Appendix A

The photoelectrons per incoming X-ray photon energy graph shown on fig. 1 is modelled on the following data[2]:

Incoming photon energy [keV]	Photoelectrons generated per detected X-ray
0.1	27
1	274
10	2740

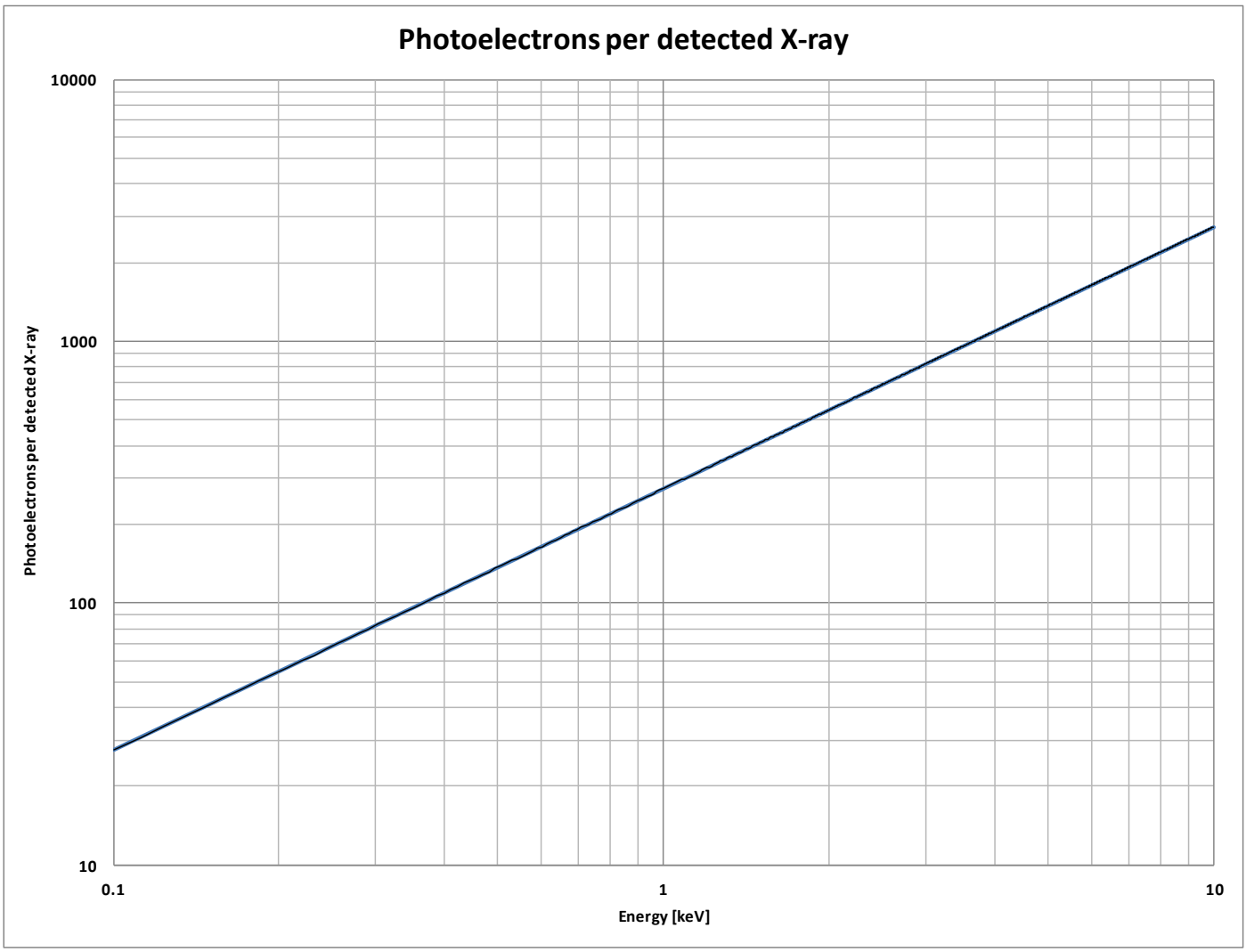

Figure 1 - Number of photo-electrons generated at a CCD/EMCCD/sCMOS sensor as a function of incoming x-ray photon energy

Useful links

[1] Product Support - http://www.andor.com/ContactSupport.aspx?type=s

[2] Technical note – direct x-ray detection http://www.andor.com/learning-academy/direct-detection-understand-direct-detection-ccds