Single Photon Detection for High-Resolution Soft X-ray RIXS

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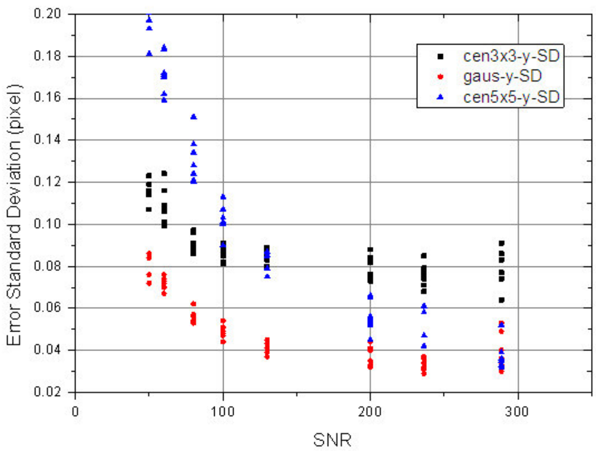
Recent advances of synchrotron technology enable the possibility of soft X-ray spectroscopy with an energy resolution in the 10's meV range. In addition to the quality of all optical components, one challenge to improve the energy resolution is the spatial resolution and efficiency of detector. For example, a detector with single photon detection and a spatial resolution better than a few microns is required to implement a spectrometer of resonant inelastic soft X-ray scattering (RIXS) which has an energy resolution in the range of tens meV [1]. For the next generation of ultra-high-resolution RIXS, a detector of sub-micron spatial resolution is demanded.

In this study, EMCCD with pixel size 13 μm is used as soft X-ray detector for RIXS beamline at Taiwan Photon Source. Sub-pixel resolution is achieved through centroid and Gaussian fitting algorithm. The accuracy of the calculated position within pixel depends on signal to noise ratio (SNR). In contrast to the widely used centroid algorithm [2,3], 2D-Gaussian distribution fitting algorithm is used. A multi-thread program is developed to efficiently spot a photon event from image and process fitting iterations to find its position within the detector pixel. The data show EMCCD can provide high SNR image. The increases of position uncertainties at pixel boundary and systematic shift to pixel center are also decreased.

The new Gaussian fitting algorithm provides more accurate photon event position than centroid with a little increase of computation loading.



The effect of SNR on position estimation error standard deviation. Three algorithms, 3×3 centroid, 5×5 centroid and 2-D Gaussian fitting are compared. The SD decreases when SNR increases. 2-D Gaussian fitting gives the more accurate position than the other two algorithms.

References

[1] C. H. Lai *et al*, J. Synchrotron Rad. 21, 325 (2014)

[2] M. R. Soman *et al*, J. Instrum. 6, C11021 (2011)

[3] M. R. Soman *et al*, J. Instrum. 8, C01046 (2013)