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Improving the resolution in soft X-ray emission spectrometers through photon-counting using an Electron Multiplying CCD

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Four years ago, a study of back-illuminated Charge-Coupled Devices (CCDs) for soft X-ray photon detection demonstrated the improvements that could be brought over more traditional micro-channel plate detectors for X-ray spectrometers based on diffraction gratings and position sensitive detectors [1]. Whilst the spatial resolution was reported to be improved dramatically, an intrinsic limit of approximately 25 micrometers was found due to the spreading of the charge cloud generated in the CCD across several pixels. To overcome this resolution limit, it is necessary to move away from the current integrated imaging methods and consider a photon-counting approach, recording the photon interaction locations to the sub-pixel level.

To make use of photon-counting techniques it is important that the individual events are separable. To maintain the throughput of the beamline for high intensity lines, higher frame rates and therefore higher readout speeds are required. With CCD based systems, the increased noise at high readout speeds can limit the photon-counting performance.

The Electron-Multiplying CCD shares a similar architecture with the standard CCD but incorporates a "gain register". This novel addition allows controllable gain to be applied to the signal before the read noise is added, therefore allowing individual events to be resolved above the noise even at much higher readout rates.

In the past, the EM-CCD has only been available with imaging areas too small to be practical in soft X-ray emission spectrometers. The current drive for large area Electron-Multiplying CCDs is opening this technology to new photon-counting applications, requiring in-depth analysis of the processes and techniques involved. Early results indicate that through the introduction of photon-counting techniques the resolution in such systems can be dramatically improved.

[1] Dinardo et al., Nucl. Instrum. Meth. A 570 (2007) 176-181

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