RIXSCam : A new detector system for RIXS beamlines

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A new high-resolution camera system has been developed for the Resonant Inelastic X-ray Scattering (RIXS) beamline, SAXES [1], at the Swiss Light Source. The system has been developed by XCAM in the United Kingdom and designed in collaboration with the Swiss team and researchers at the Open University in the UK. The new camera system utilises photon counting, with event centroiding, to improve the resolution of the spectrometer. We describe the improvements using the new RIXSCam system, together with performance testing taken during commissioning at the ADRESS beamline.

Introduction

SAXES, the RIXS spectrometer at the Swiss Light Source (SLS), has been upgraded to improve the resolution of the entire instrument. The detector is an important part of this upgrade. Ultimately, the spectrometer will have a resolution (ΔE) of <15 meV at 500 eV (R~30,000).

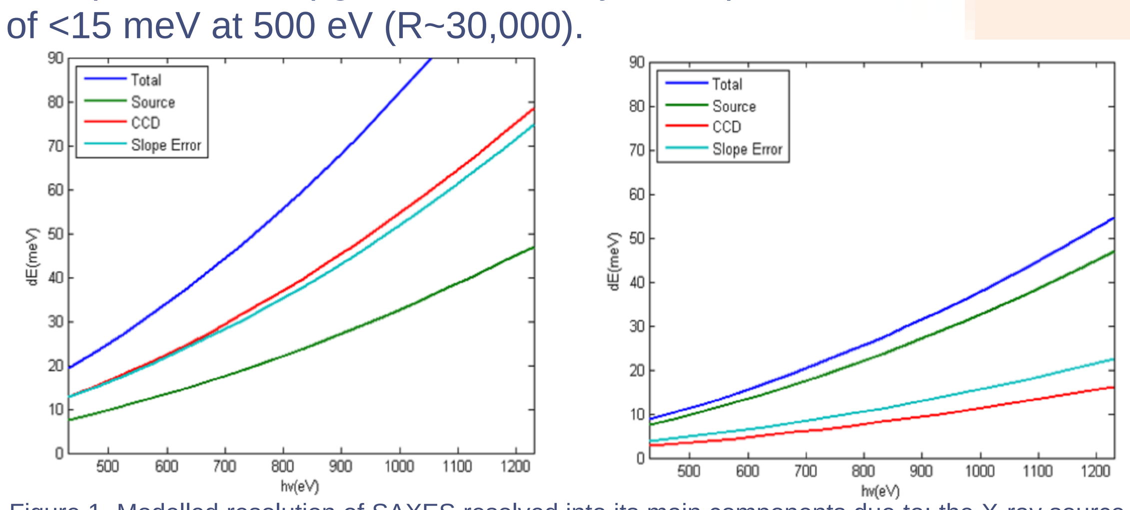


Figure 1. Modelled resolution of SAXES resolved into its main components due to; the X-ray source size, the error in the slope of the diffraction grating and the CCD resolution before (left) and after (right) the envisioned upgrade. The CCD had been the dominant source of uncertainty until the upgrade [2].

Improving the X-ray Spatial Resolution

One key improvement is the semi-custom CCD detectors used to improve the spatial resolution. Figure 2 shows one of the new EM CCDs used in the camera.

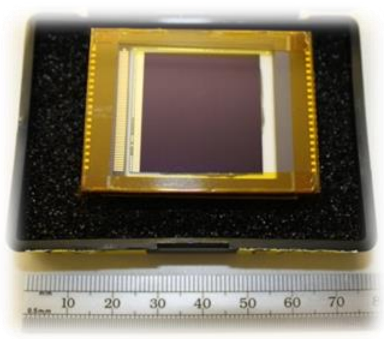


Figure 2. The detector used in the camera system

The intrinsic spatial resolution of the CCDs is ~24 μm FWHM [2] – this can be reduced to 2-3 μm through centroiding the individual X-ray photons [3,4]. The electron-multiplying CCDs can greatly increase signal-to-noise ratio. Figure 3 shows an image with four distinct X-ray photons. Figure 4 shows the improved spatial resolution obtained using centroiding compared to a pixel at the PoLuX beamline.

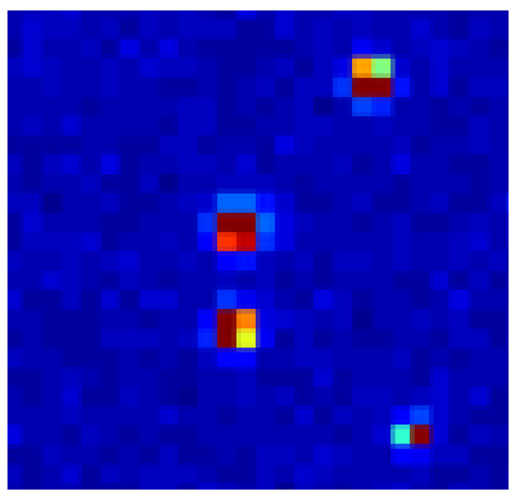


Figure 3. Centroiding of the detection events using the results of the detector characterisation [3].

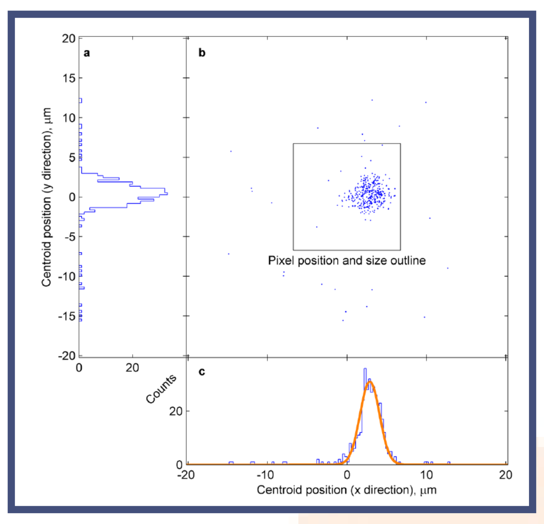


Figure 4. Centroiding of the detection events using the results of the detector characterisation [3].

Design of the system

XCAM Ltd designed the camera head which incorporates electronics which control the system and cooling for the detectors using a PCC refrigerator. The camera is assembled using UHV practices. This design accommodates up to 3 detectors to increase photon throughput, and these are mounted onto a rotating cold bench to give further increase in the projected spatial resolution, and energy resolution.

Key specifications

Energy Range	200-3000	eV
Maximum active area	78.33 x 25.73	mm^2
Active pixels (H x V) (for 3 CCDs)	4896 x 1608	
Pixel size	16	μm
Readout rate	3	MHz
Frame Rate	1	Hz
System noise photon counting mode	<1	e- rms
System noise integrating mode/ e-	12 typ.	e- rms.
Detector angle of incidence	10-90	°
Vacuum compatibility	10^{-9}	mbar
Temperature Control	-110	°C
Post-processed resolution (@90°)	<5	μm

The RIXSCam^{TM} system on SAXES

The RIXSCam^{TM} is the resulting camera system, designed by XCAM in collaboration with the scientists at the Open University and the Paul Scherrer Institute. Figure 5 shows the thee CCDs on the rotating optical bench, whilst Figures 6 and 7 show the camera system installed on the ADRESS beamline at the SLS.

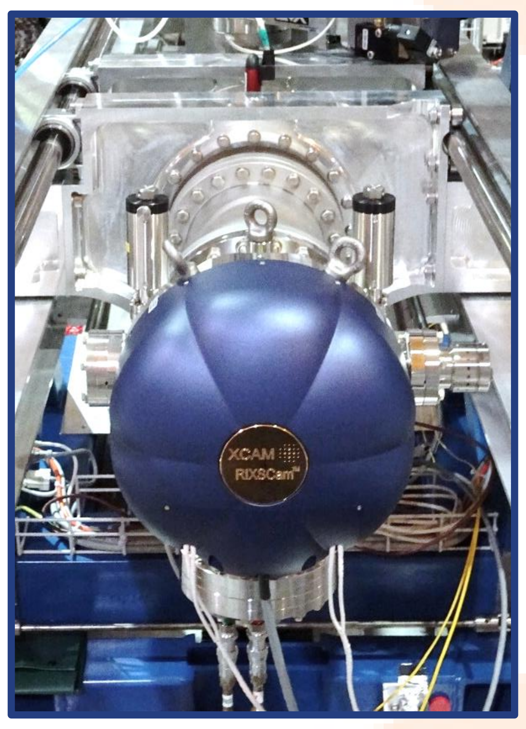
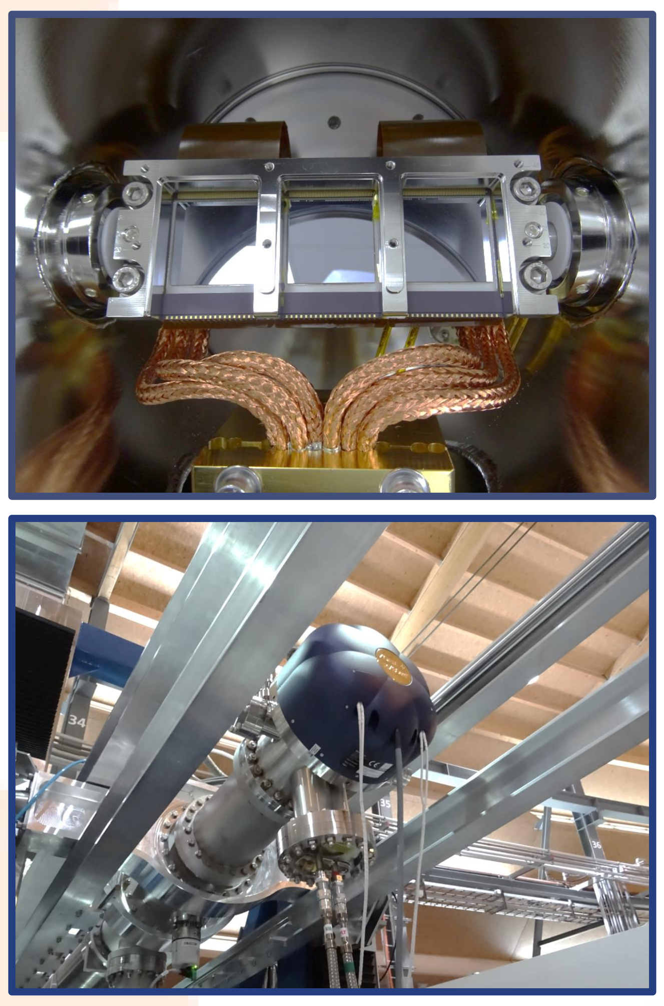


Figure 5. The RIXSCam installed at the end of the ADRESS beamline at the SLS. rotatable cold bench with 3 EM CCDs installed inside the RIXSCam.



Figures 6 & 7. The rotatable cold bench with 3 EM CCDs installed inside the RIXSCam and further detail of the system mounted on the ADRESS beamline

Results

Figure 8 gives results taken during the commissioning of the RIXSCam^{TM} system on the SAXES beamline at SLS in May. The top image shows a stack of 100 images containing individual photons, whose interaction centroids were calculated, shown in the central pane. The across-dispersion counts are then accumulated using a quadratic iso-linear correction to account for beam shape, to accumulate a final spectrum. The data was taken at an incidence angle of 20° which improves the overall resolution.

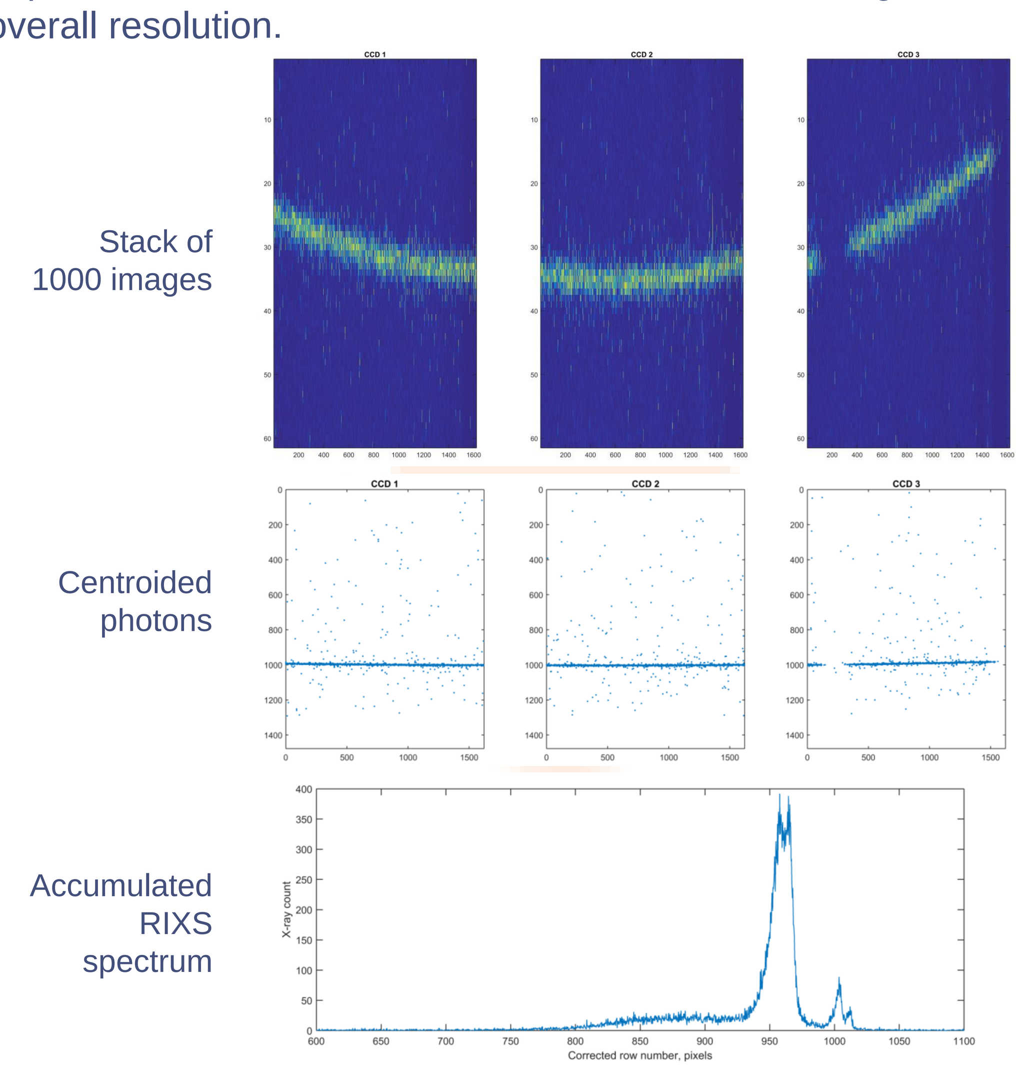


Figure 8. Images of an X-ray spectrum, with derived photon centroids, and ultimate spectrum

Conclusion

RIXS is an important analysis technique for synchrotron research. Here we have reported the development of a new high-resolution camera system, working in collaboration with scientists at PSI and the Open University. The new camera system is operating on the SAXES beamline, and uses photon counting with event centroiding to achieve a FWHM spatial resolution of <5 μm, and is yielding a total system energy resolution of <45 meV at 500 eV, and we anticipate an improvement to this figure shortly resulting from further beamline improvements. The camera system has been fully commissioned, and is now operating for user experiments at SAXES providing both increased throughput and higher resolution.

References

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