High Resolution Camera for RIXS

Summary of Topics

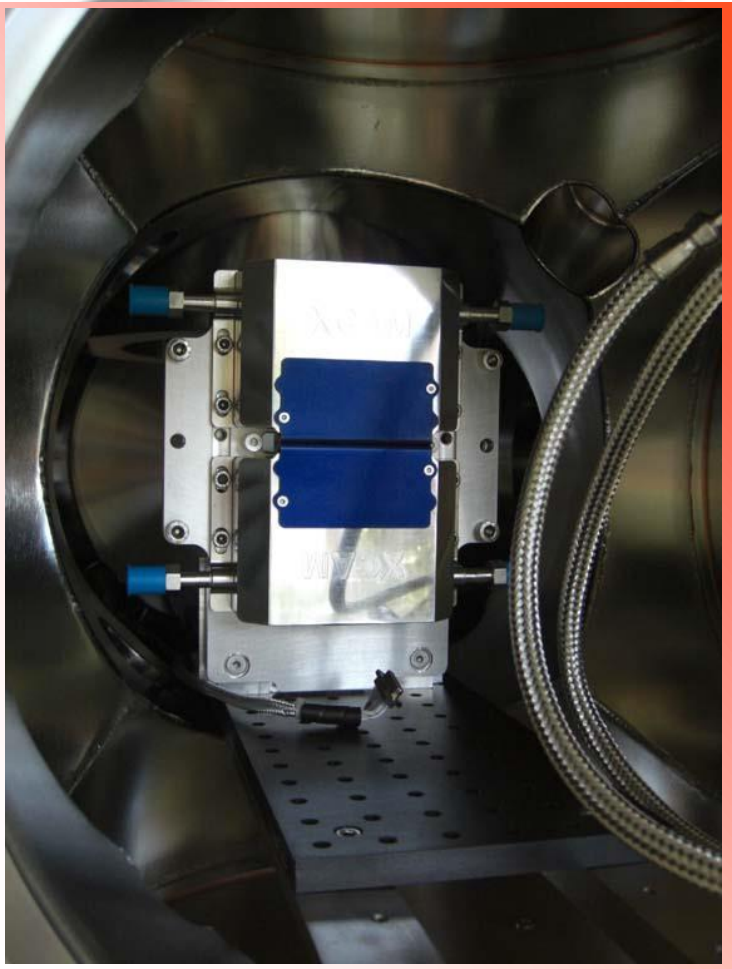
- XCAM background
- Facilities
- X-ray, EUV cameras for Imaging and Spectroscopy
- Photon Counting soft X-ray Spectroscopy
- RIXSCam

Celebrating XCAM's 20th Year

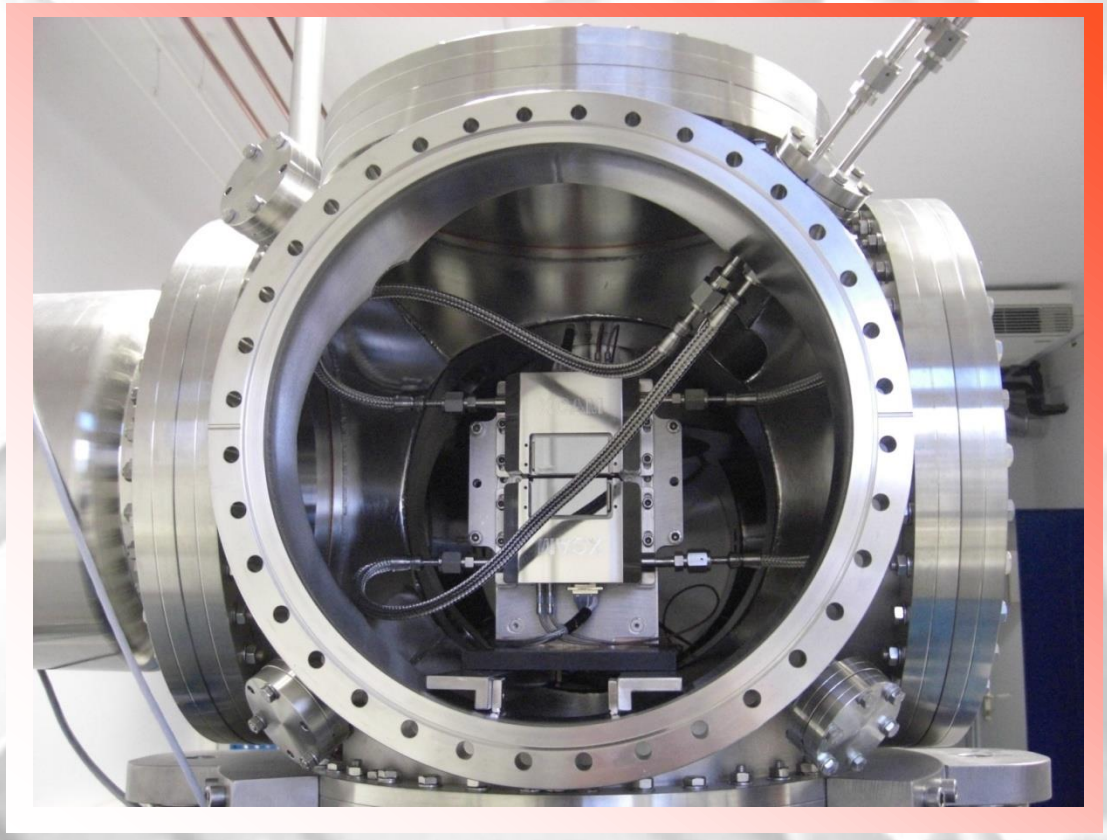
Moved to new 7000 sq. ft. factory in 2012

With two class 1000 cleanrooms, plus development and production labs

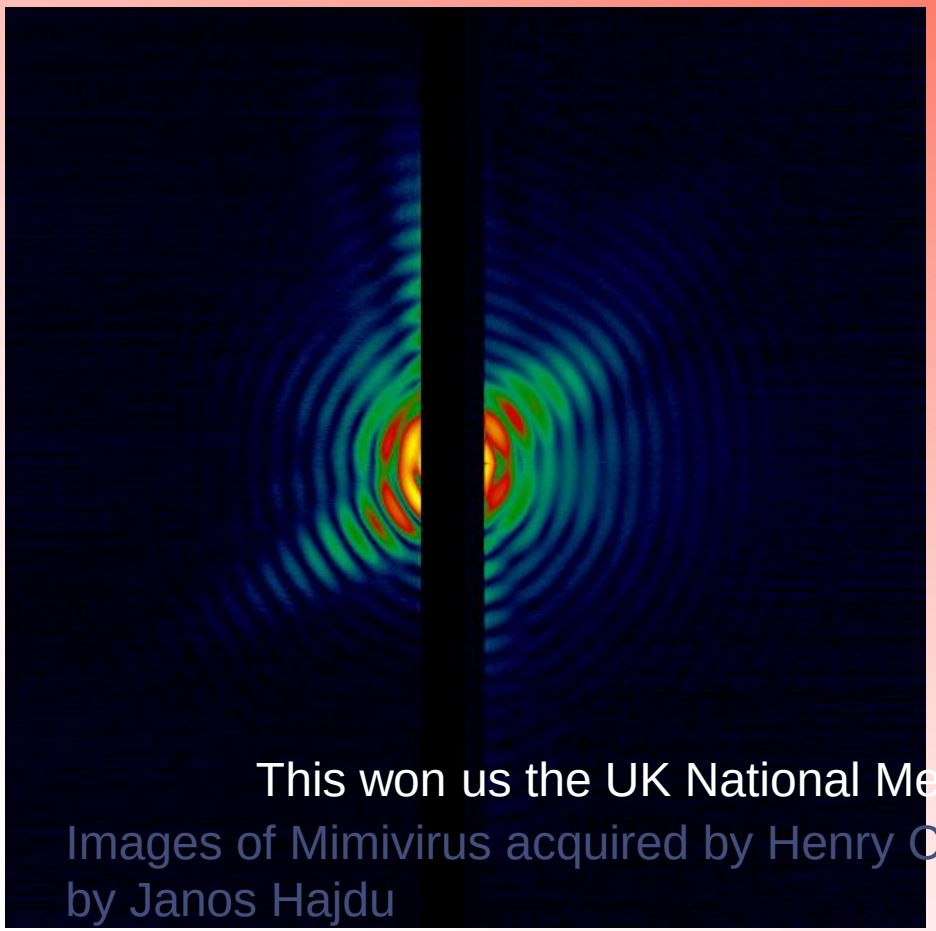
Our DESY FLASH Camera system being commissioned

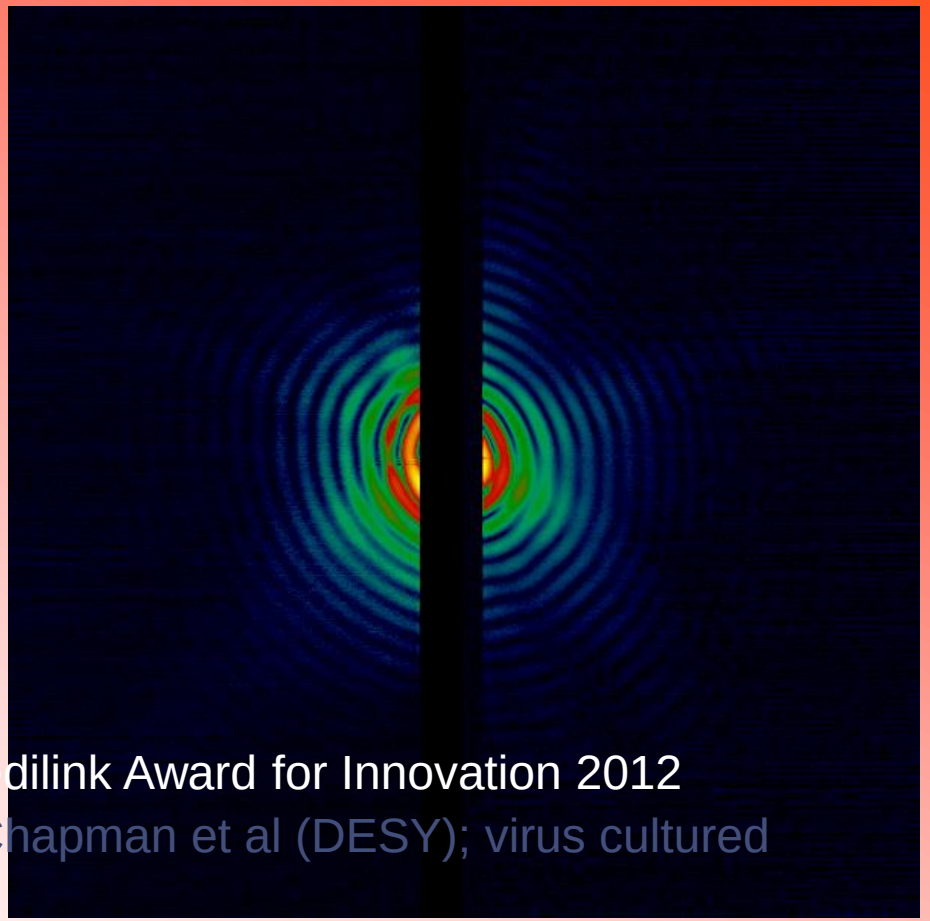


Dual Unit camera undergoing commissioning in vacuum chamber



The world's First Diffraction Images of a Mimivirus, taken with our Camera, using the World's First X-ray Laser to Illuminate





This won us the UK National Medilink Award for Innovation 2012

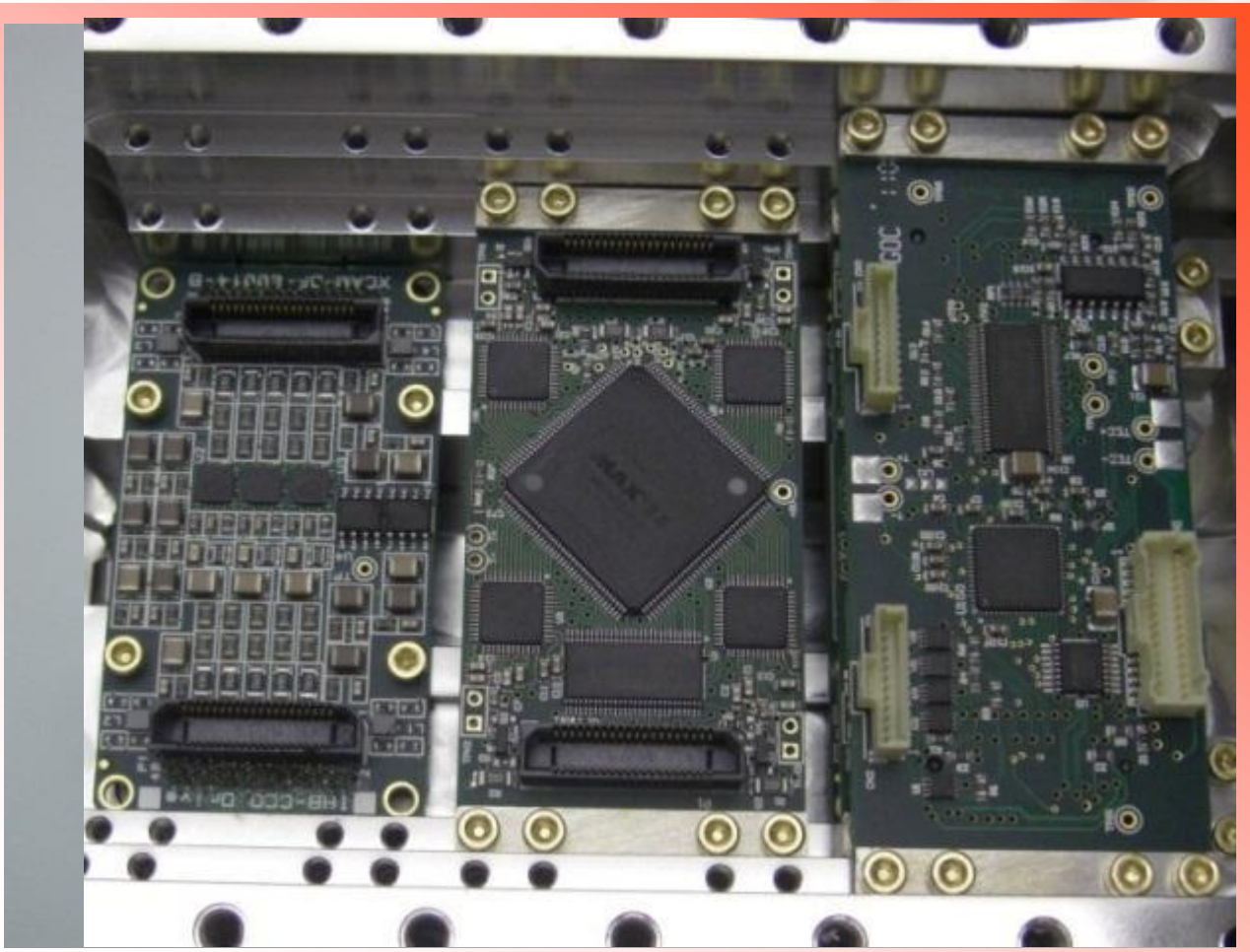
Images of Mimivirus acquired by Henry Chapman et al (DESY); virus cultured by Janos Hajdu

Super-Clean UCV Cameras for Use in Vacuum Systems at EUV Wavelenths

First industrial cameras supplied for UCV applications in 2010

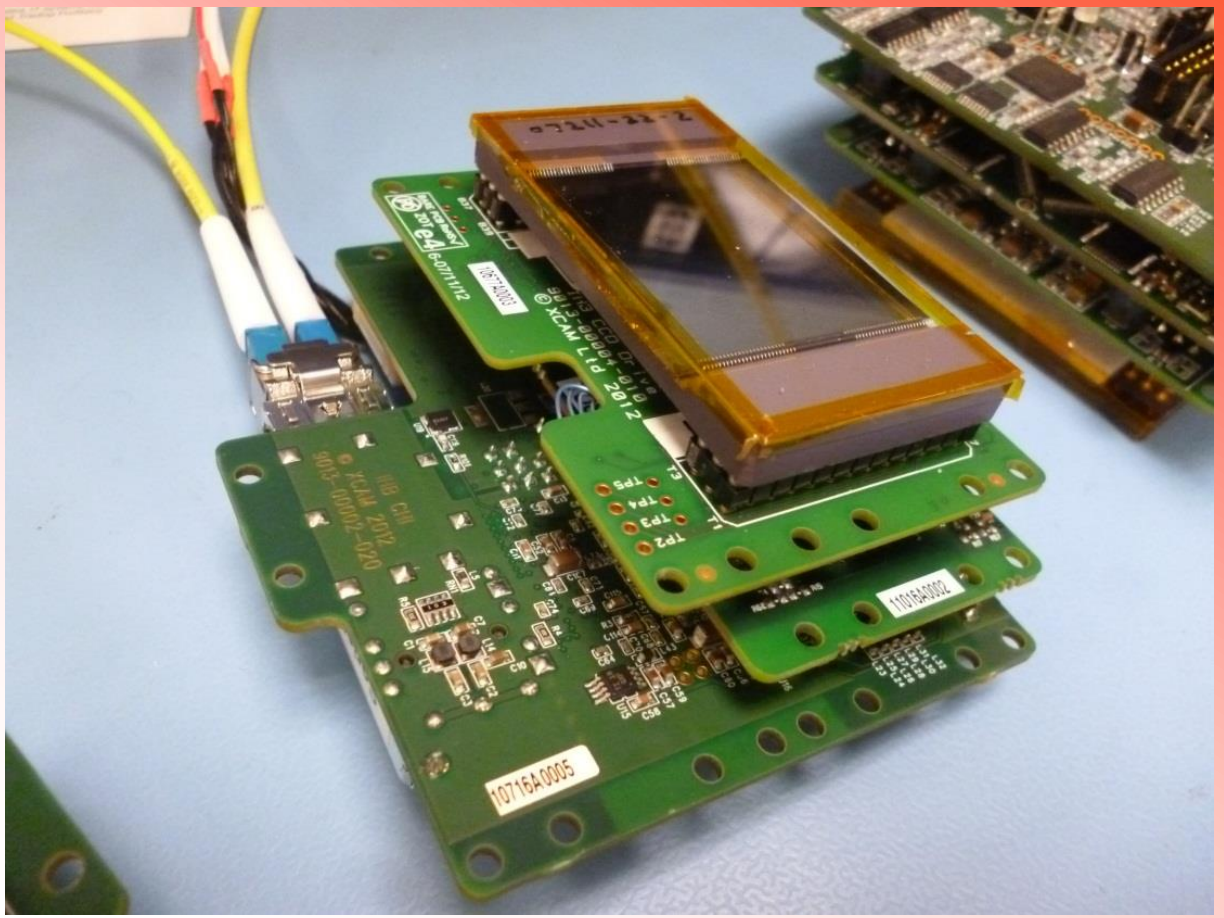
With electrical interfaces/ cabling

Now moved on and current vacuum cameras have super-clean fibre optic data transfer

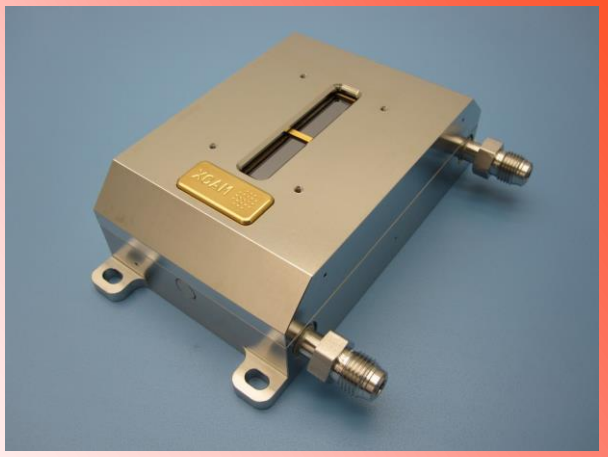


Cameras for UCV with Ultra-Clean Fibre Optic Interfaces

Now produce fibre optic camera-link out for high noise immunity ultra-clean applications – often used inside fully vacuum immersive cameras



Dual CCD4210 camera head for readout of X-ray Grating Images – University Iowa

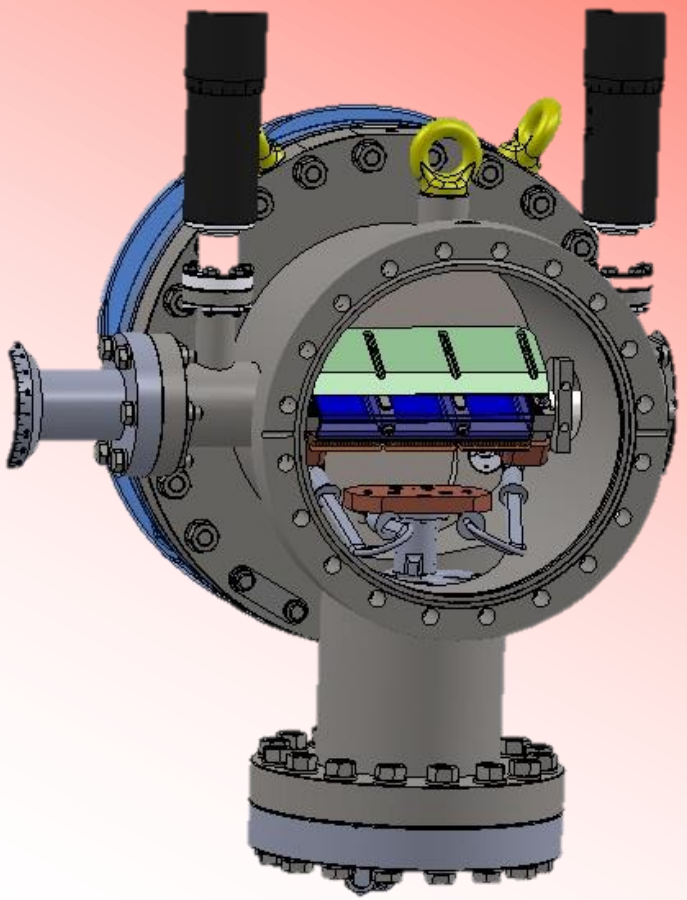


Dual enhanced mode no AR coat CCD4210 built for IXO grating development at Iowa University, USA; used in tests at Iowa and Marshall.

This was a custom camera which we designed for Iowa University for their development of an IXO diffraction grating. It houses two no AR coat CCD4210 detectors in a single camera. It has been used in tests at Iowa University and Marshall.

This customer returned, asking us to build a 4 x EMCCD (CCD207-40) camera for their sounding rocket experiment

Multi-EM Fibre Optic CCD Cameras For Resonant Inelastic X-ray Scattering Experiments

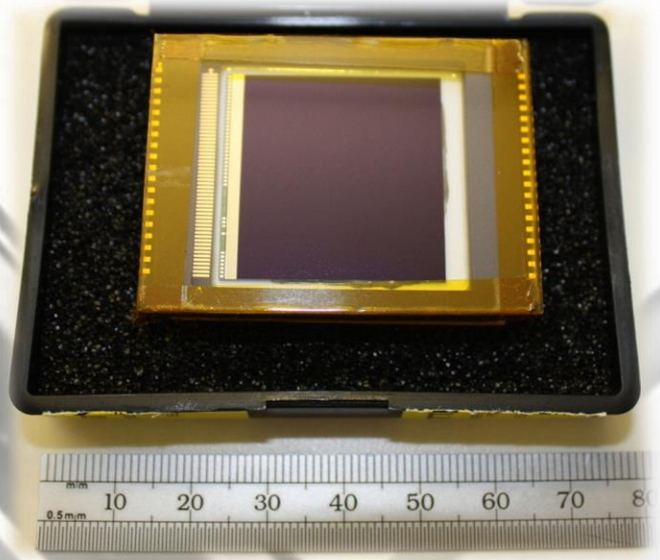


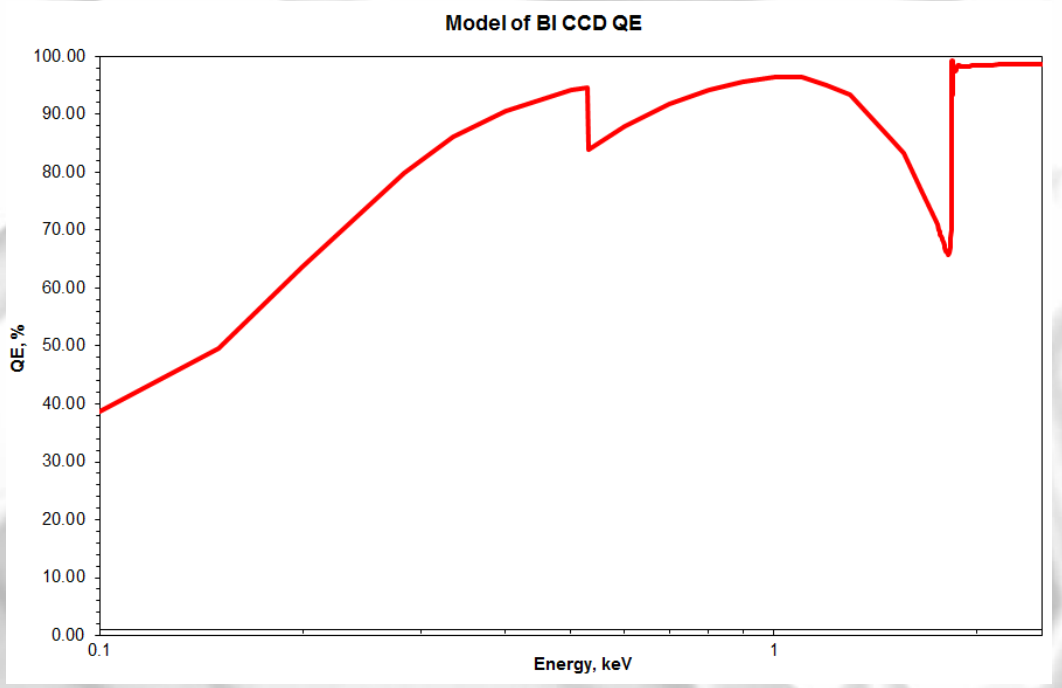
Custom camera design with 3 off CCD207-40 EMCCDs (26mm square EMCCD with 16 micron pixels.

- Large area for dispersed spectrum
- Sub-electron read noise for single photon detection
- Sub-pixel resolution – below 5 micron resolution using licensed algorithm which takes pixel edge effects into account
- Back-illuminated, no AR coating for excellent soft x-ray response
- Cryogenic cooling to below -70ºC for use in photon counting or integrating mode

EM CCDs for X-ray Photon Counting

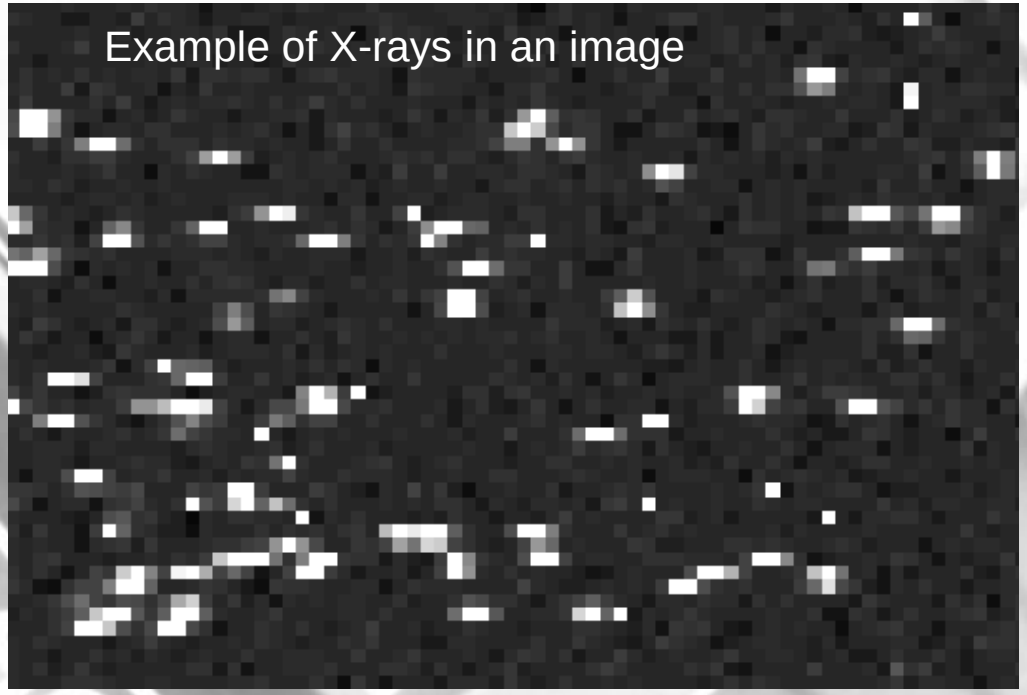
- The EM CCD can perform photon counting due to sub-electron e.n.c.
- Performance can be maintained at readout rates >10 Mpix/s
- Back-illuminated architecture can allow single photon detection in the 100eV – 10 keV range

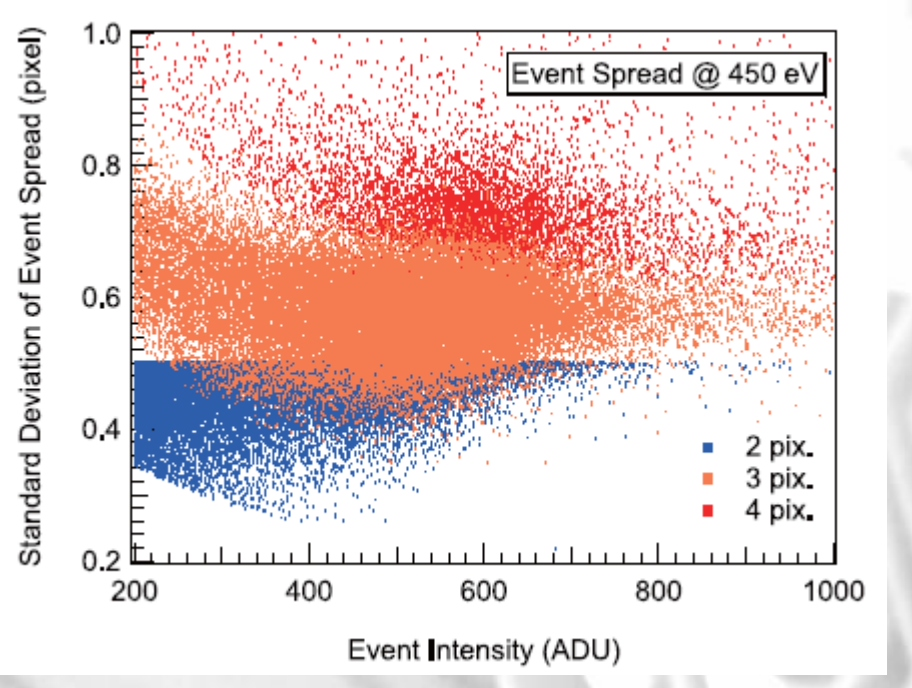




Event Spreading in Photon Counting Mode

- X-ray events spread and are collected in several pixels
- On-chip binning can be used to UVSOR used 4x1 binning which increases the S/N for the centroiding
- UVSOR-II found a typical charge cloud radius of $1\sigma = 9.6\ \mu m$



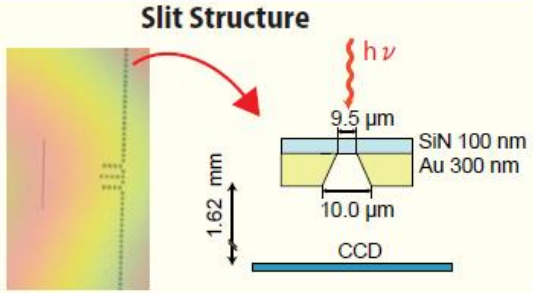


Spatial Resolution – UVSOR-II

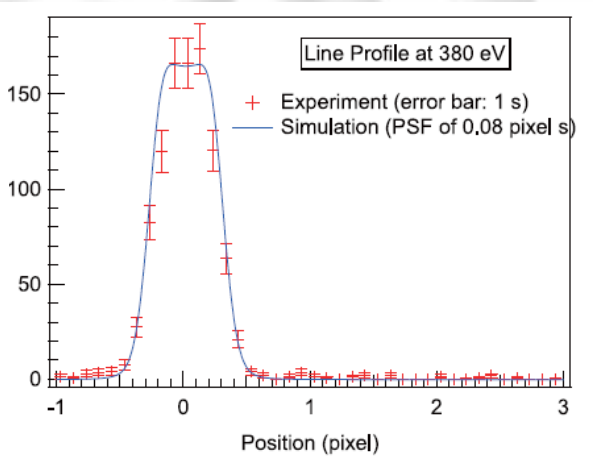
Initial results using an EM CCD for RIXS were developed by XCAM and UVSOR-II from 2006

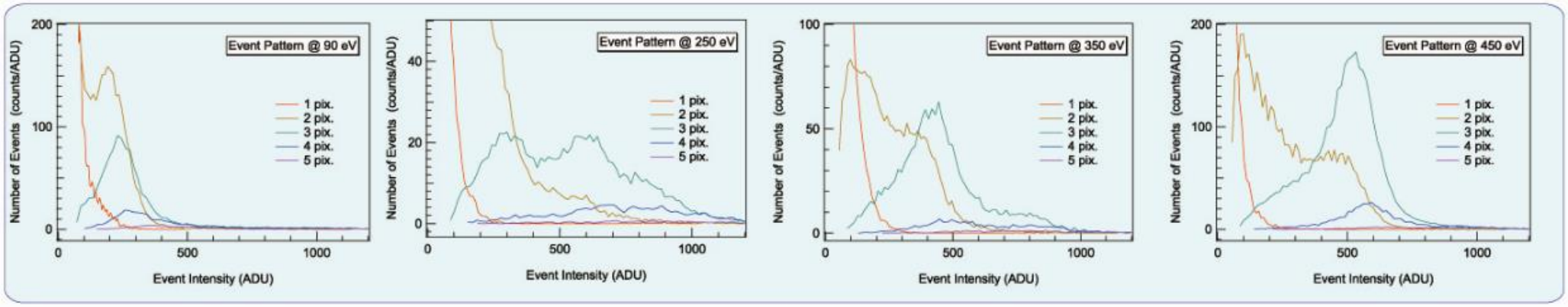
Derived a FWHM spatial resolution of 3.0 μm at 380 eV

4 x 1 binning
Mag ~100
400 kHz/pixel
Frame rate 10 Hz
Recorded area
516 x 516 pixels



Sub-pixel spatial resolution was successfuly optained by using electron multiplying CCD.
By assuming Gaussian profile for the point-spread function (PSF) of the detector, the PSF was estimated to have
Standard Deviation: 0.08 pixel (1.3 μm)
FWHM: 0.19 pixel (3.0 μm)



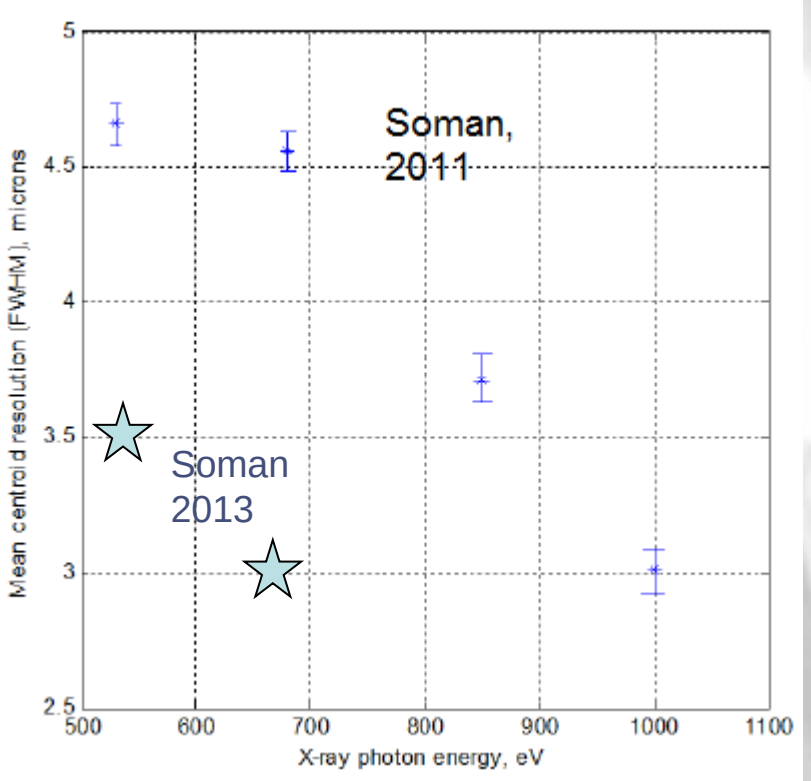


Development of the Centroiding Technique for RIXS by PSI-OU

- A collaboration between PSI and the Open University between 2011-2014 looked at improved resolution for RIXS
- This exploratory work used XCAM camera electronics)
- Initial results from Soman gave FWHM vs energy in 2011 and were later improved by 2013 now achieving **down to 2 μm**
- The event centroiding technique has now been licenced to XCAM for development of their cameras for RIXS

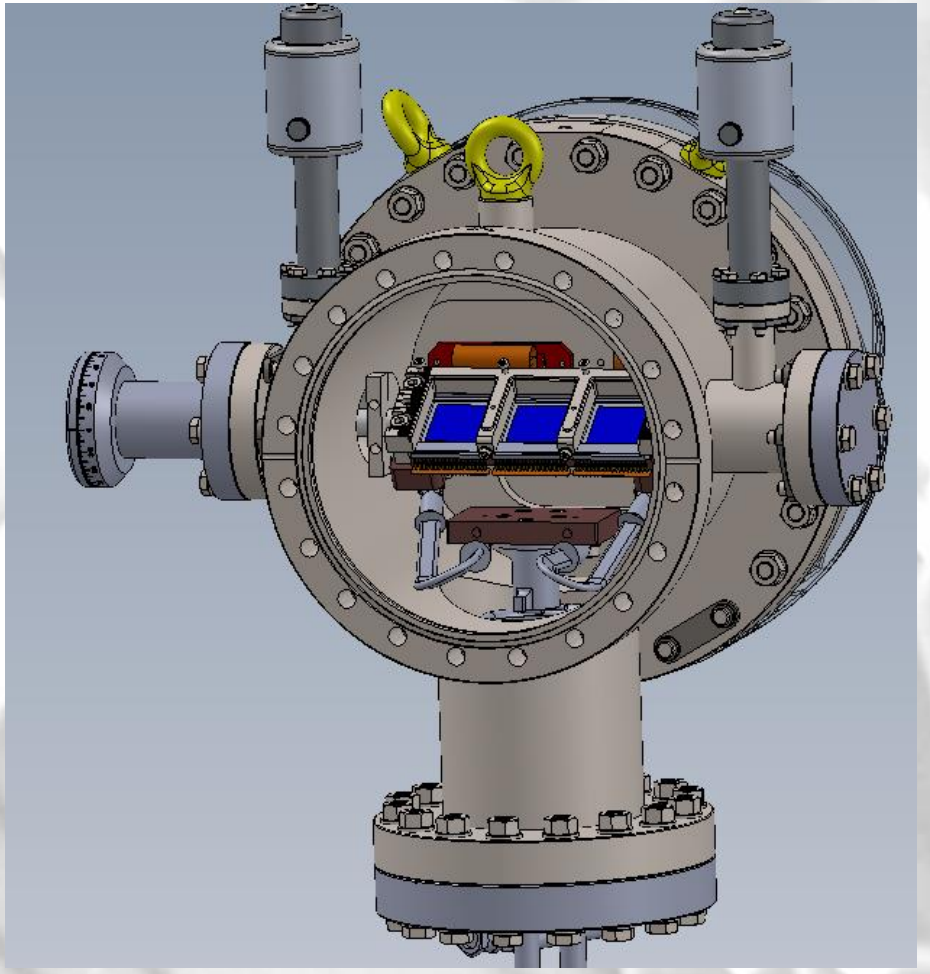
Table 7.2. Spatial resolution (FWHM) achieved with the corrected centre of gravity algorithm applied across a 3×3 pixel area, as measured by a Gaussian profile fit to the PSF for each energy data set and in each direction. Errors are less than 0.004 μm.

Photon energy	850 eV	1000 eV
x direction, μm	2.15	2.09
y direction, μm	1.93	1.87



RIXSCam using 3 large area EM CCDs

- XCAM is currently developing a new generation of cameras for RIXS
- The first will be a triple large area EM CCD207
- Intrinsic spatial resolution will be <5 μm in normal-incidence
- CCDs will be on a rotatable bench to enable alteration of gamma for improved resolution
- Camera will be constructed using UCV techniques compatible with ultra-clean vacuum systems



Summary

- XCAM is now in its 20th year providing camera systems into scientific applications
- XCAM is now offering a range of cameras for RIXS applications
  - High detection efficiency in the 0.1-3 keV band
  - Operating in photon counting mode with event centroiding
  - Achieves a spatial FWHM of 3 μm in normal incidence
  - Current frame rates of ~2 Hz
- Systems will be operational at PSI, BNL during 2015-2016
- Future systems may adopt new deep-depleted, back illuminated monolithic CMOS sensors, and systems are keeping abreast of sensor developments