



Science & Technology
Facilities Council

HEXITEC

HIGH ENERGY X-RAY IMAGING TECHNOLOGY

Development of a Spectroscopic X-Ray Imaging Camera

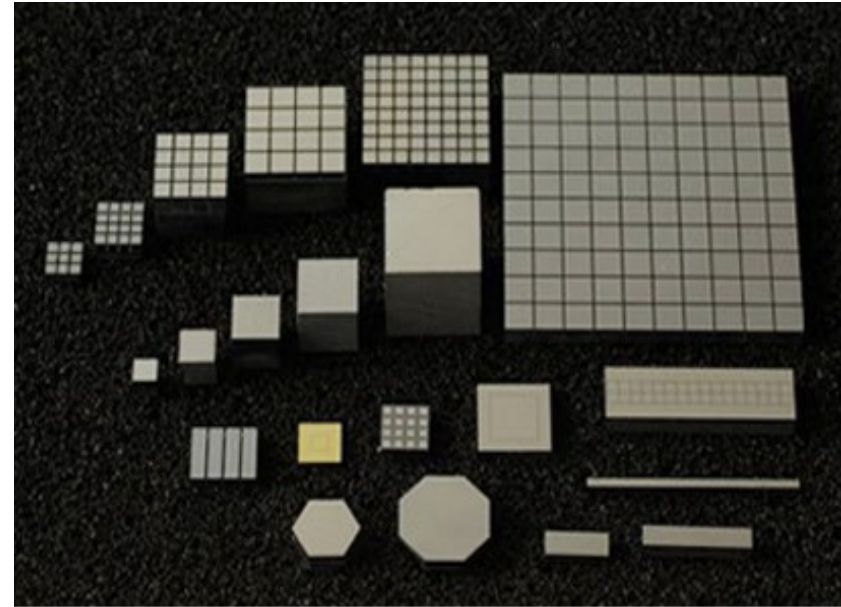
Dr. Matthew C. Veale



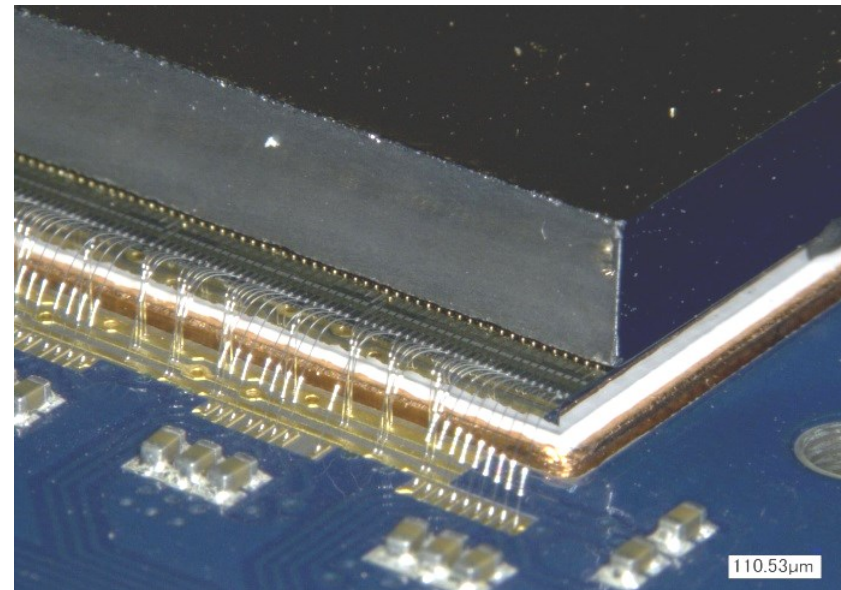
11 – 14 March 2018 – Annecy, France

The Technology

- Cd(Zn)Te Detectors
 - High density
 - Wide band gap (room temp)
 - Good electron transport
 - Small pixel fabrication

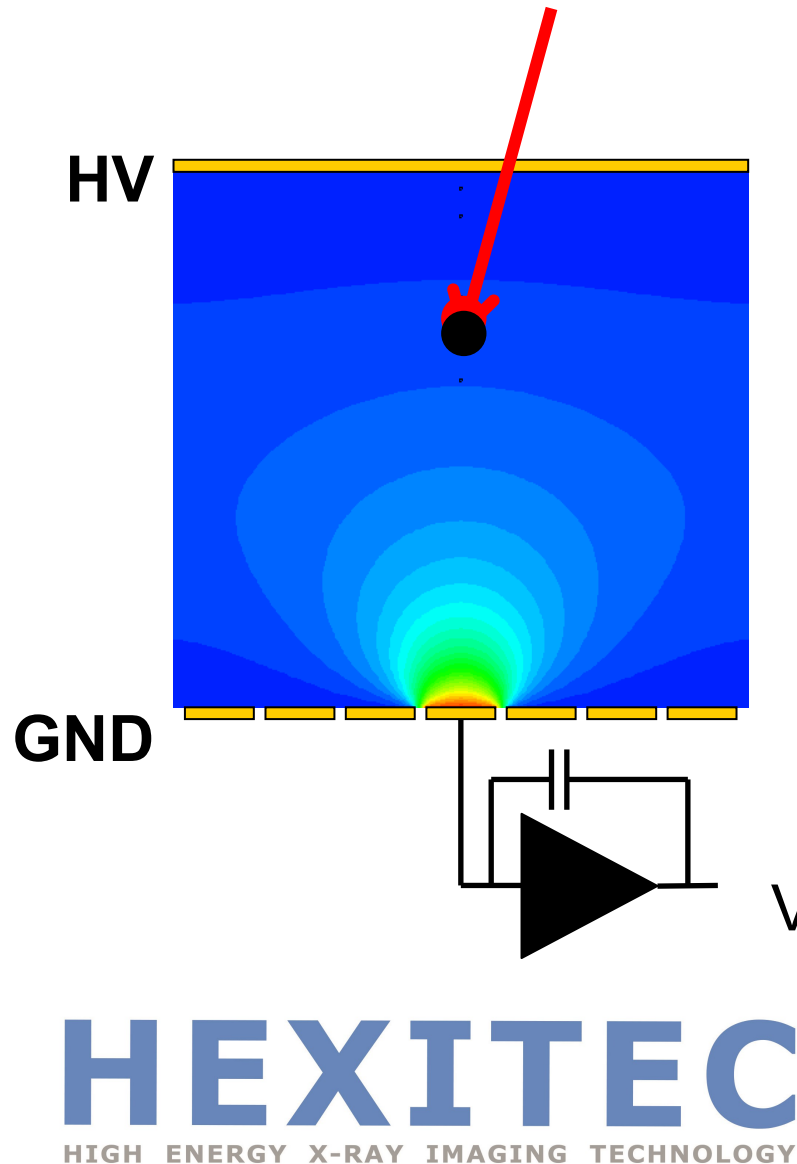


- HEXITEC ASIC
 - 80 x 80 pixels
 - 250 μm pixel pitch
 - High Gain: 2 – 200 keV
 - Low Gain: 6 – 600 keV
 - Energy Resolution \sim 800 eV

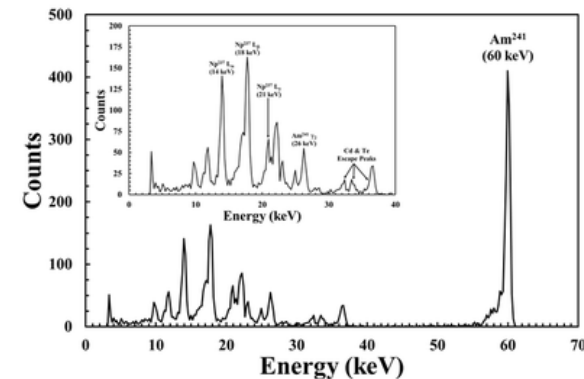
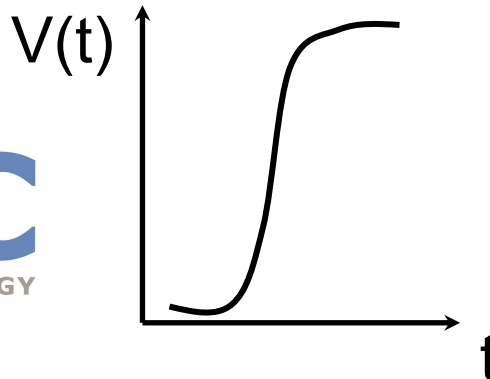


- Interconnect @ STFC

How Does it Work?

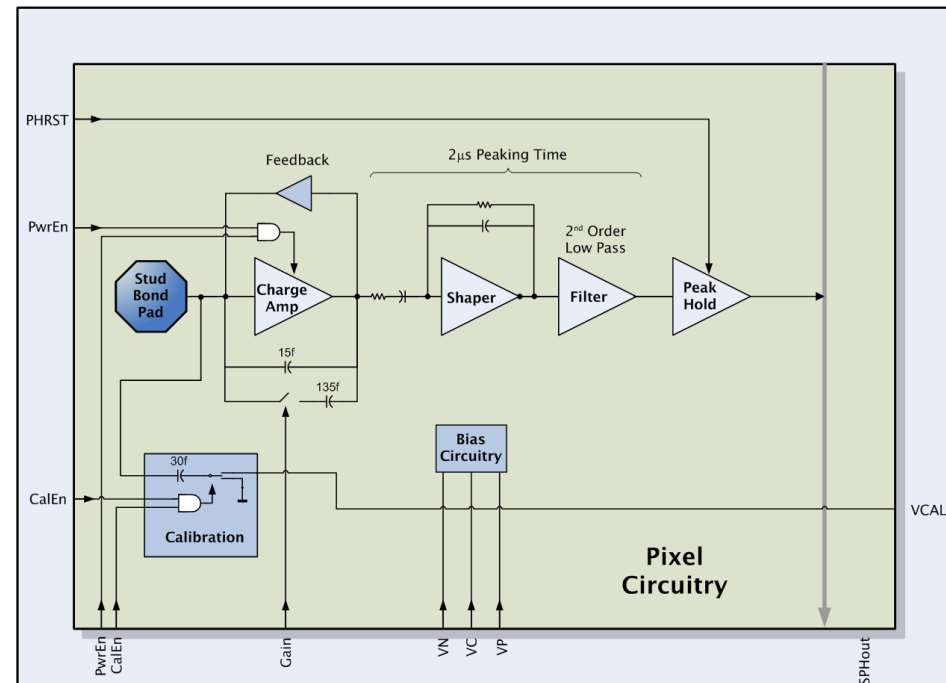
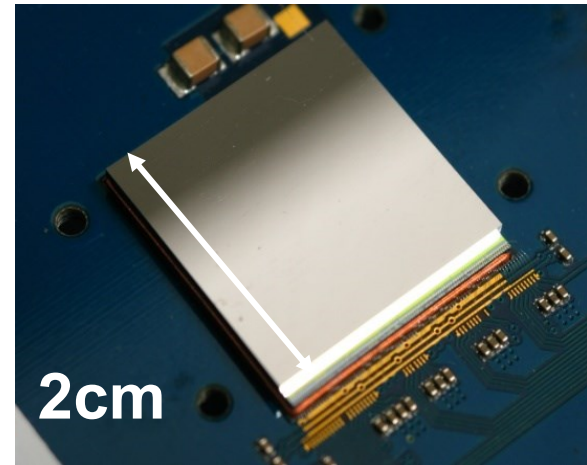


- The ASIC is flip-chip-bonded to the Cd(Zn)Te.
- X-rays generate electron-hole pairs.
- Carriers drift under the applied electric field.
- Charge induced on pixels during drift.

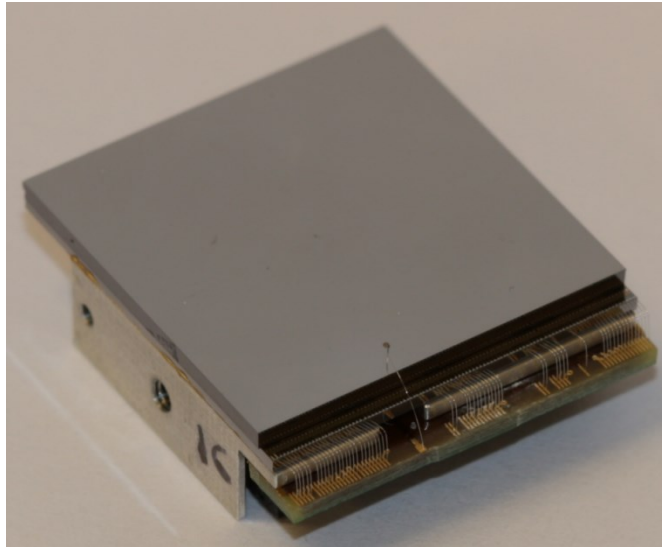


Simplicity = Spectroscopy

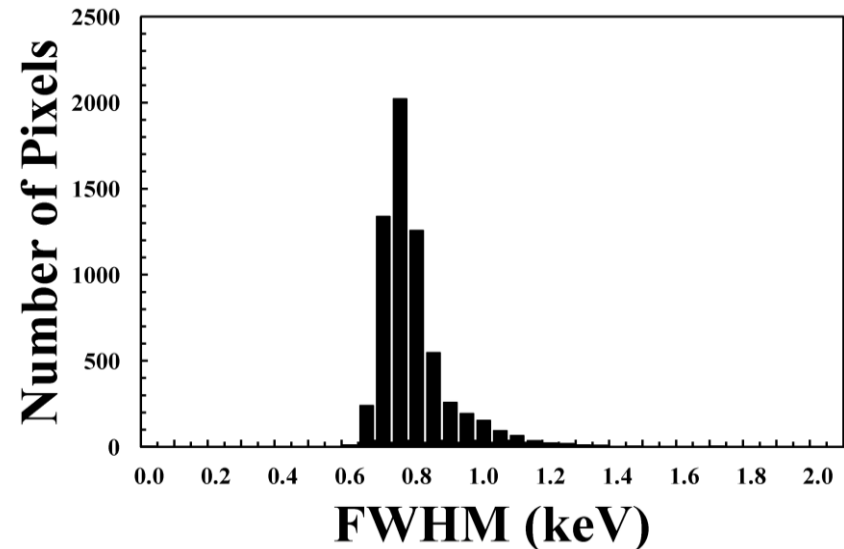
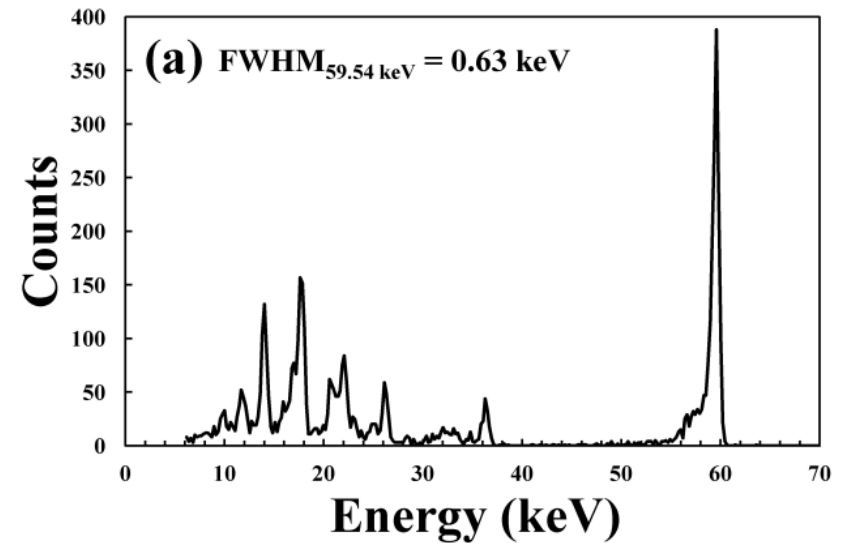
- Our design philosophy was simplicity.
- Design was optimised for high resolution spectroscopy, not rate.
- Charge sensitive preamp with leakage compensation.
- $2\mu\text{s}$ shaper stage.
- Peak hold circuit $\rightarrow V = kE$.



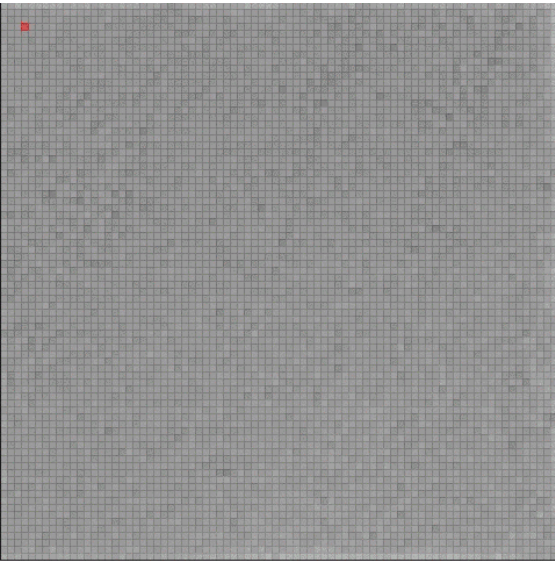
Spectroscopic Performance



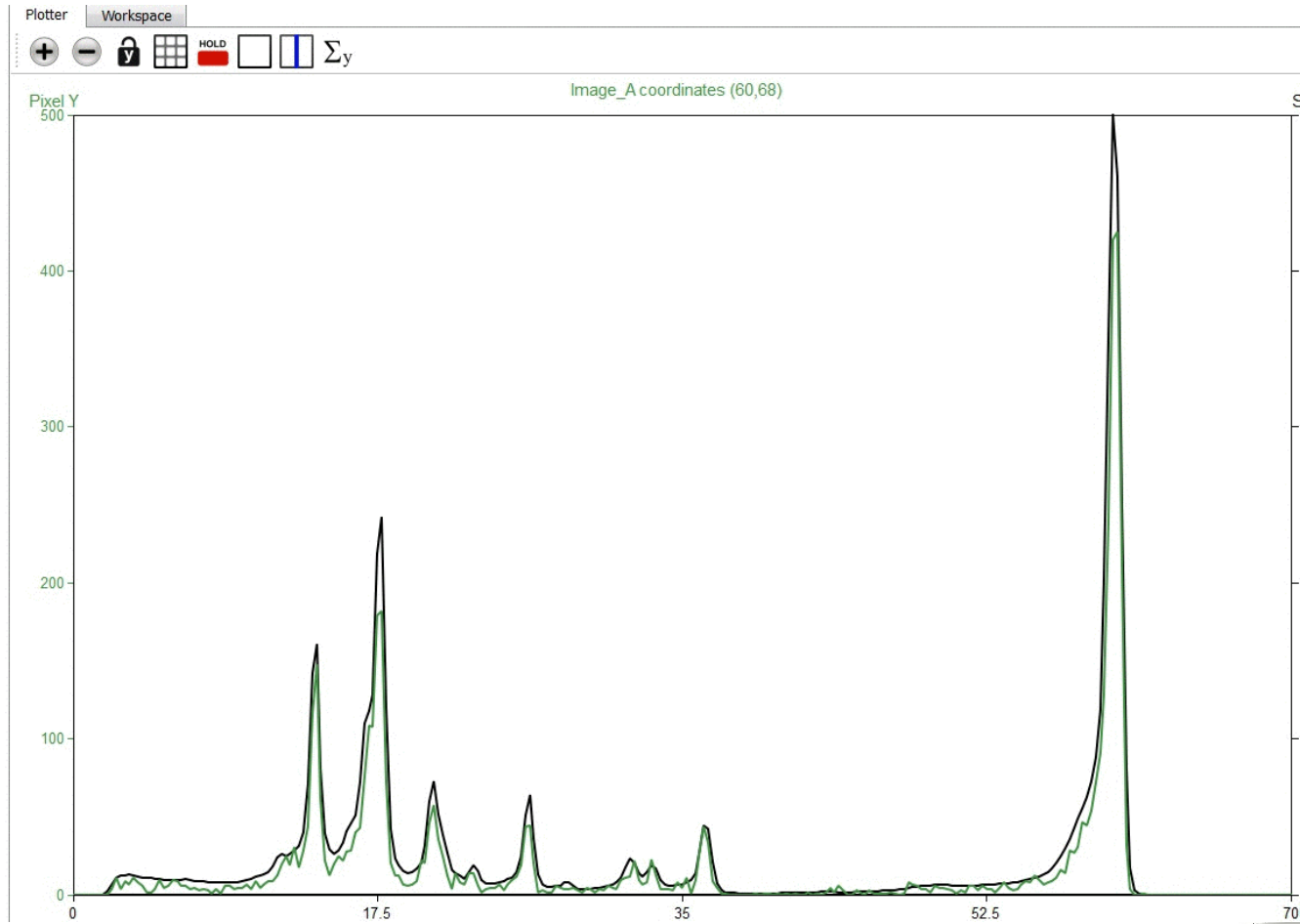
- 1mm Acrorad CdTe @ 30°C.
- > 99% of pixels have a $\text{FWHM}_{@60\text{keV}}$ of < 2 keV.
- Mean FWHM = 0.8 keV.



Spectroscopic Performance



Am-241



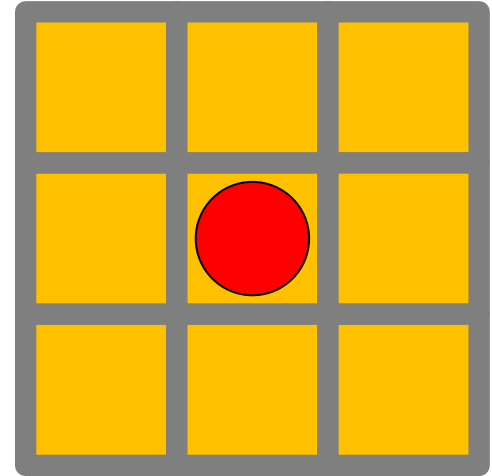
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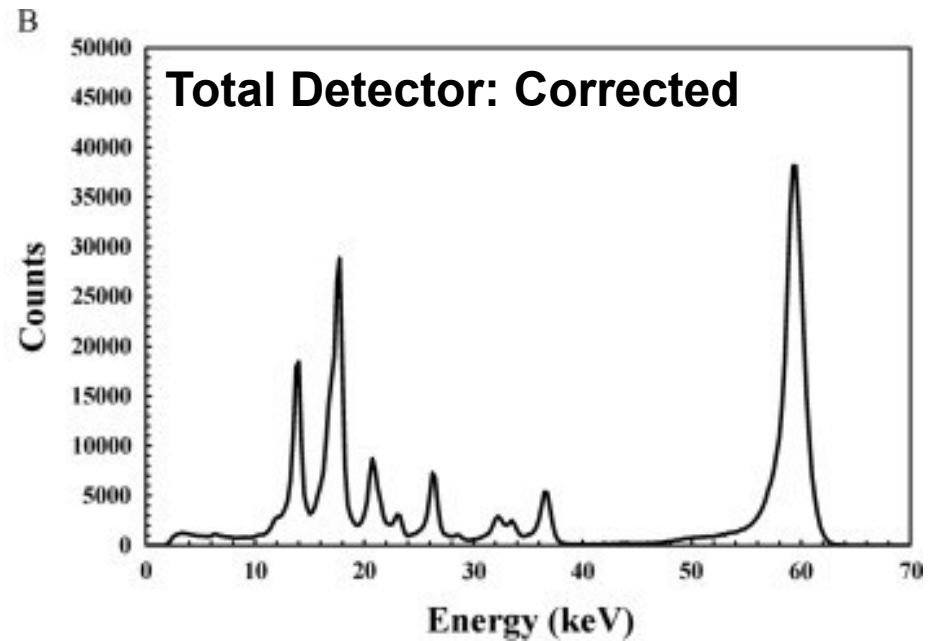
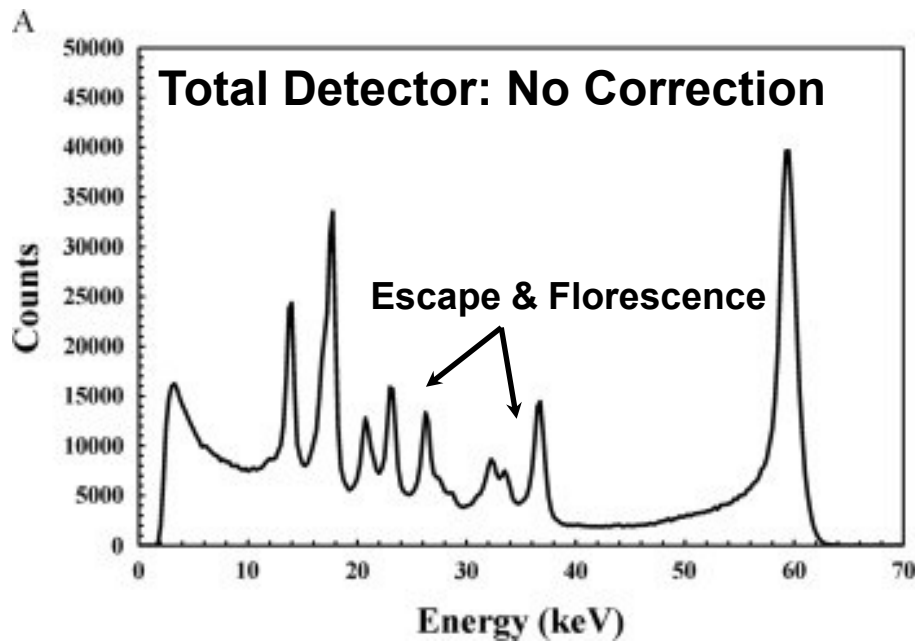
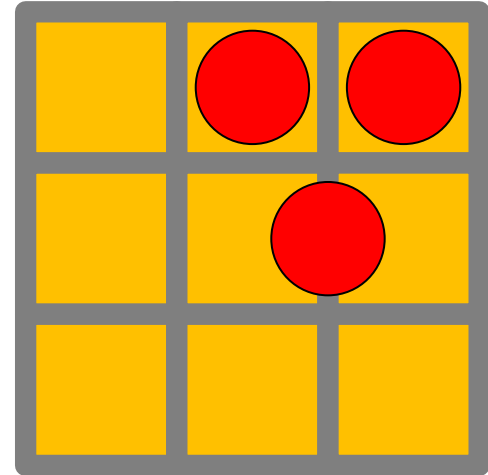
Count Rate Limitations

- Readout @ 10 KHz.
- Pixel Size = 250 μm
- Max Rate = $1.6 \times 10^5 \text{ ph s}^{-1} \text{ mm}^{-2}$??

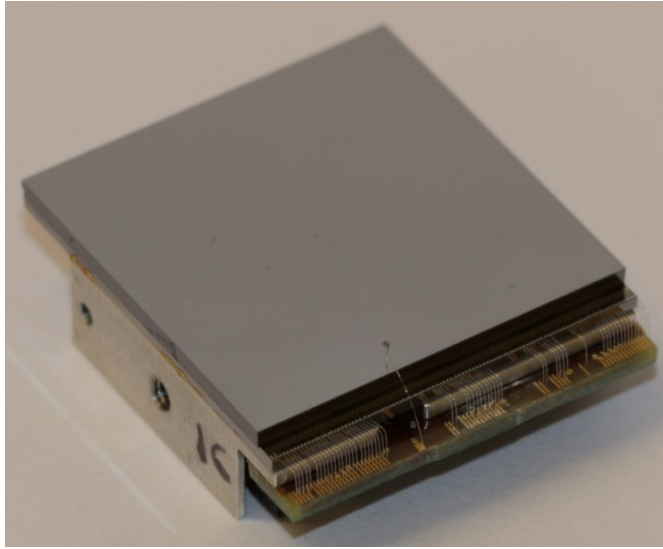


Count Rate Limitations

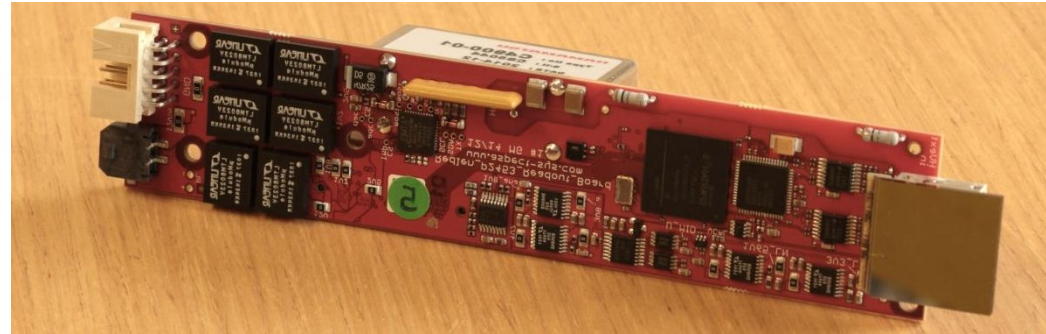
- Readout @ 10 KHz.
- Pixel Size = 250 μm
- Max Rate = $1.6 \times 10^5 \text{ ph s}^{-1} \text{ mm}^{-2}$??
- In reality $< 2.0 \times 10^4 \text{ ph s}^{-1} \text{ mm}^{-2}$.
- Need low occupancy for charge sharing.



HEXITEC: GigE System



- 3-side-butable module design.
- 2015: Plug-and-Play GigE system
- Designed for easy integration.
- Systems available commercially.



HEXITEC DETECTOR

08 August, 2016 / Comments Off / In Product / By QD

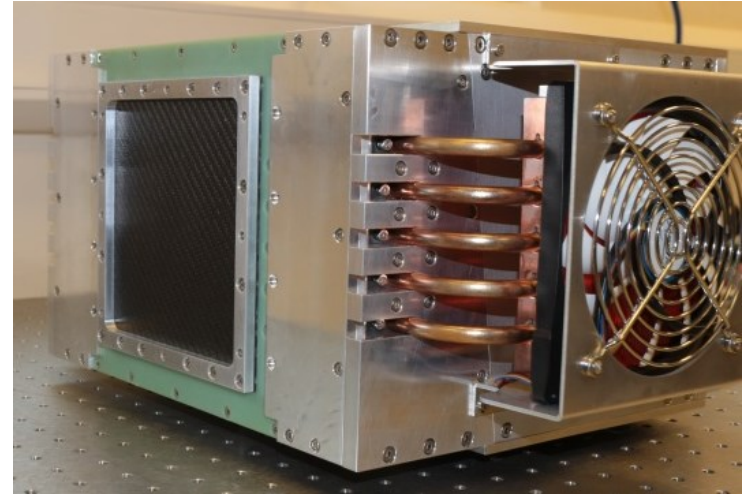
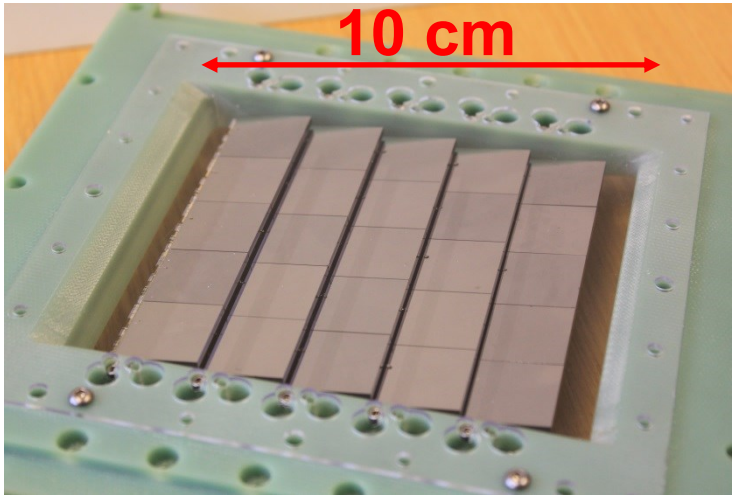
A Fully Spectroscopic Hard X-Ray Imaging Detector

The HEXITEC detector measures the energy and position of every incident photon in the 4-200keV range. Each one of the 80 x 80 pixels provides a full energy spectrum with an average energy resolution of 800eV FWHM at 60keV. It is a self-contained module that only requires a mains power supply and connection to a PC or Laptop. It can be supplied with a user friendly GUI to operate the detector and provide calibrated spectra per pixel or industry standard Gig-E Vision APIs for users to integrate into their own systems.

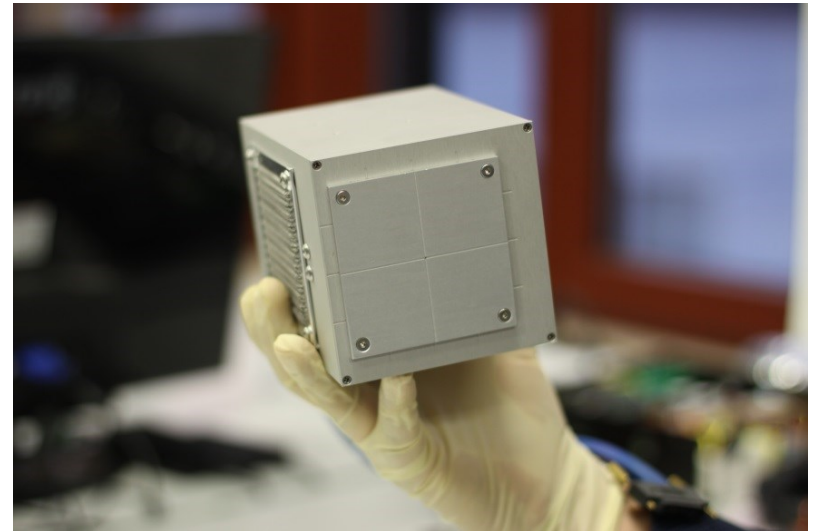


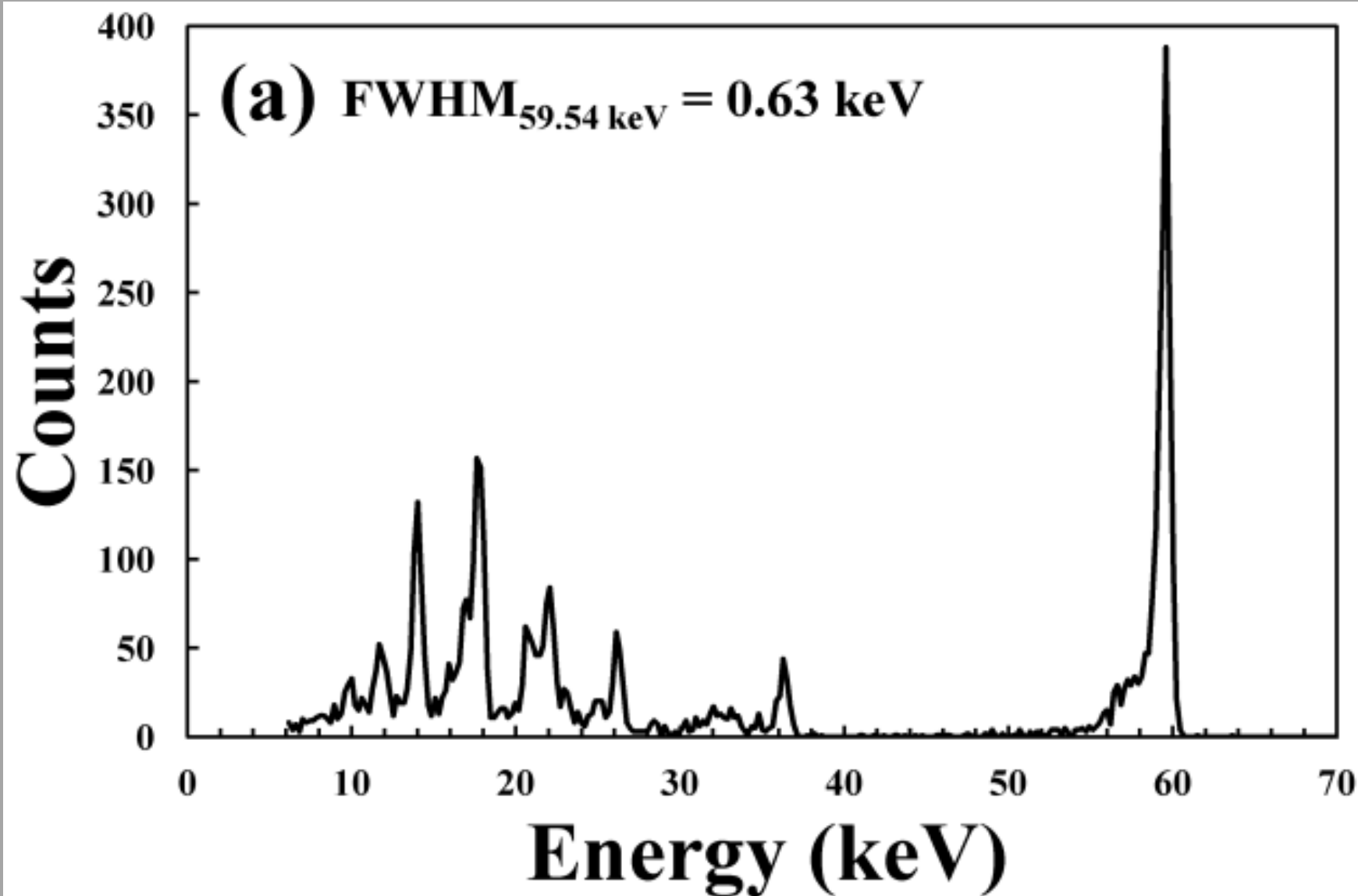
<http://quantumdetectors.com/hexitec/>

Large Area HEXITEC



- 3-side-buttable module design.
- 2014: 10cm x 10cm system.
- 2017: 2nd system commissioned.
- 2018: 2 × 2 USB 3.0 system.





Science Case Studies

Materials
Science

Archaeology

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Illicit
Material
Detection

Medical
Imaging

Solar
Physics

Laser-
Driven
Radiation
Sources

Understanding Alloys



I12 + B16 Beamlines

T. Connolly, I. Dolbnya, K. Sawhney



Technology Dept.

M. Veale, M. Wilson, P. Seller



Oxford University

E. Liotti, A. Lui, A. Malandain,
P. Grant

Results Published:

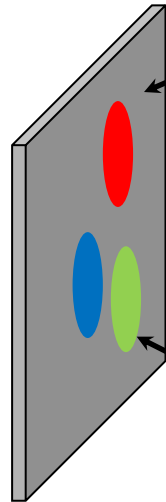
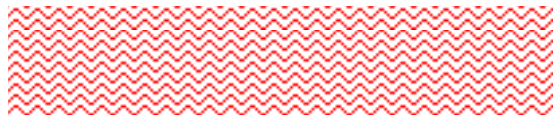
E. Liotti et al

Nature Scientific Reports 5 (2015)

doi:10.1038/srep15988

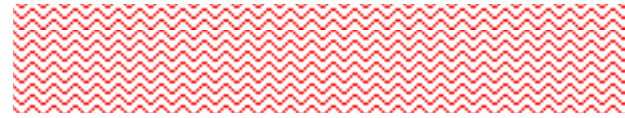
Traditional Imaging

X-Rays



Al:Cu Alloy

Ag, Zr, Mo
Impurities



Temperature
Controlled Furnace
(25 – 1000°C)

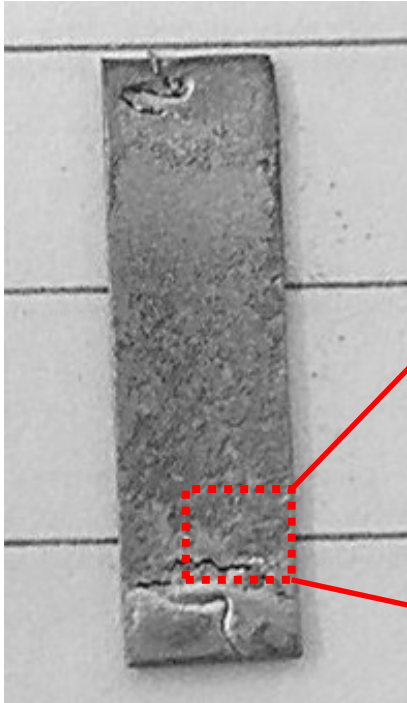


LYSO Scintillator +
CCD

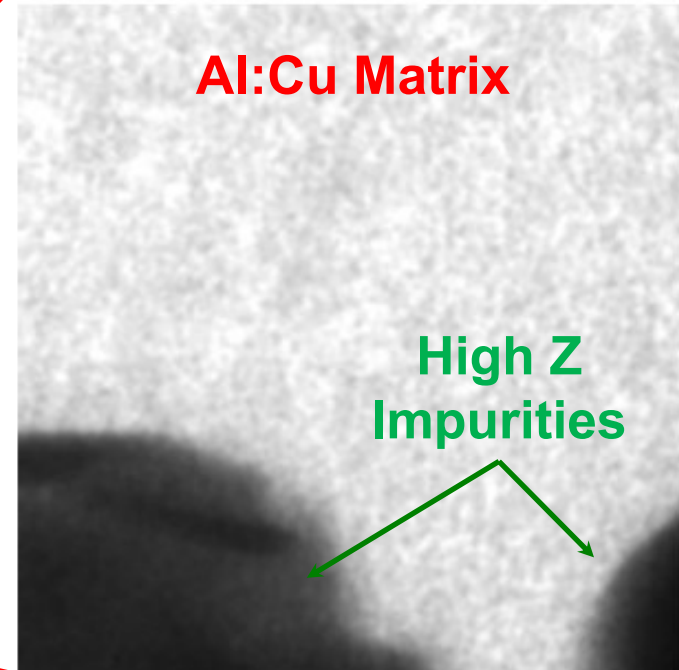


Traditional Imaging

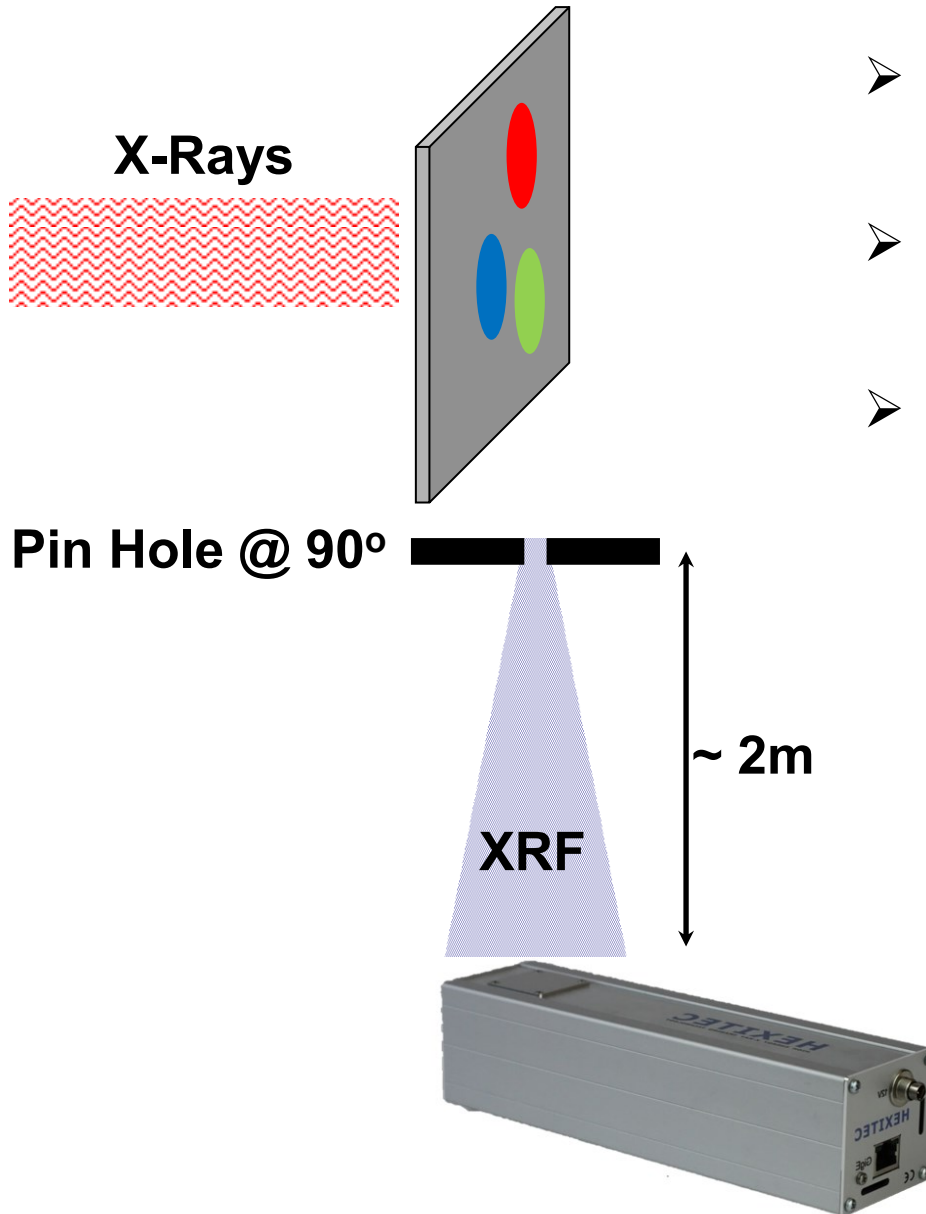
Al:Cu Alloy



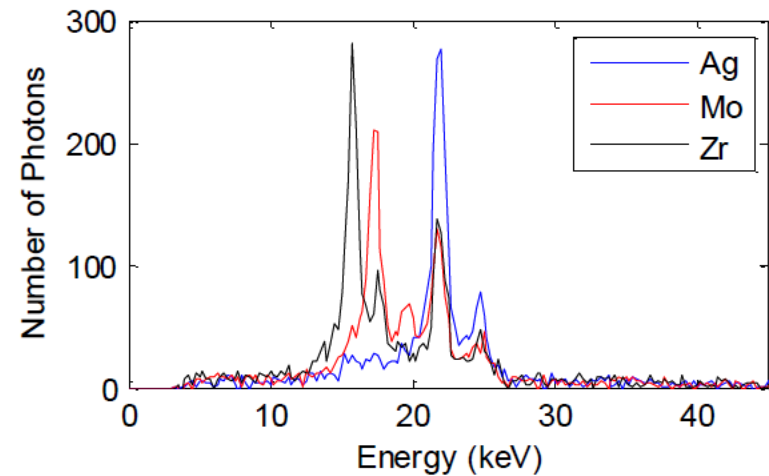
Transmission Image

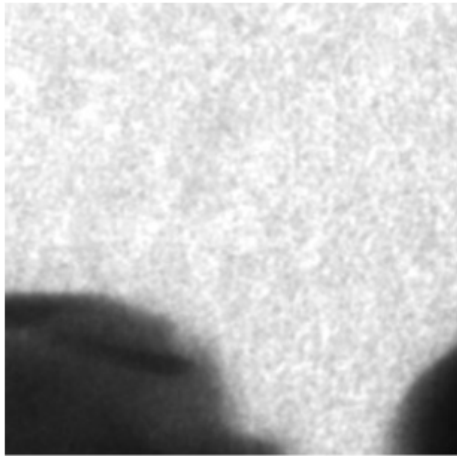


HEXITEC XRF Imaging

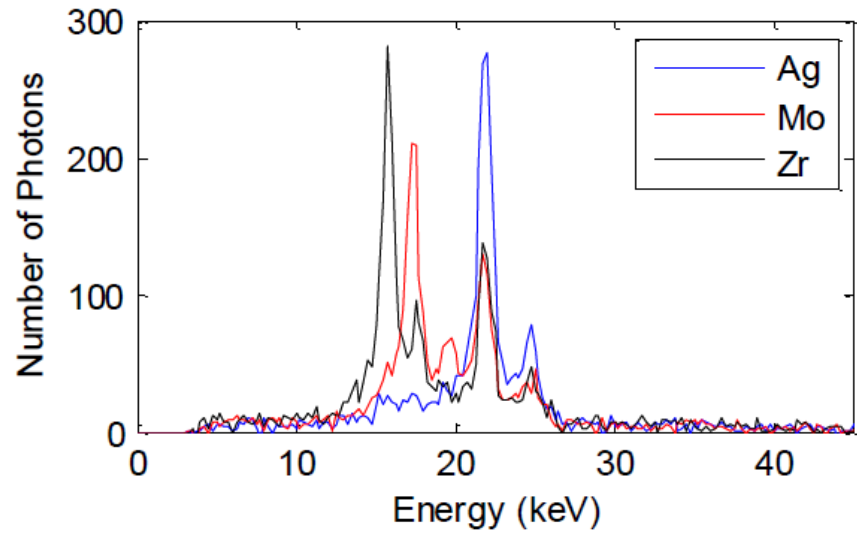


- **HEXITEC @ 90° to sample.**
- **100 μ m pinhole used for imaging.**
- **Spectroscopy allows individual elements to be identified.**

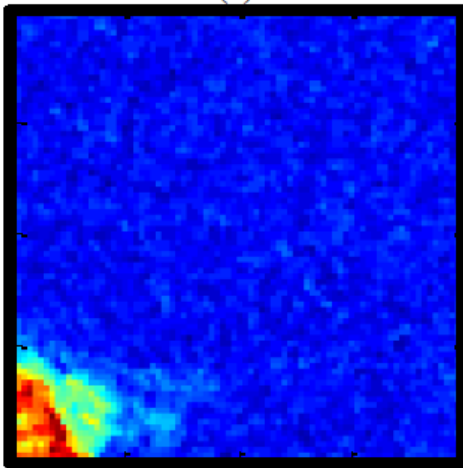




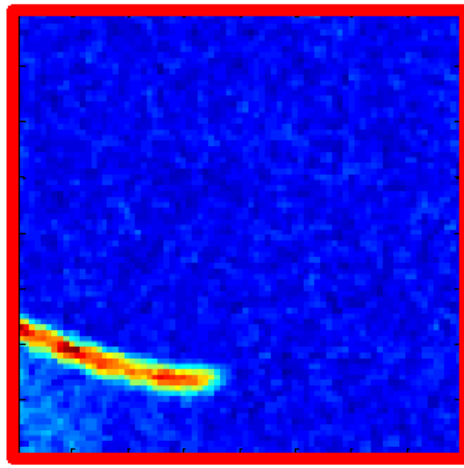
(a)



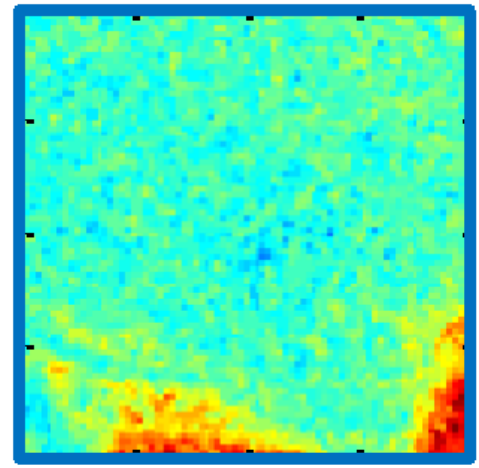
(b)



(c)

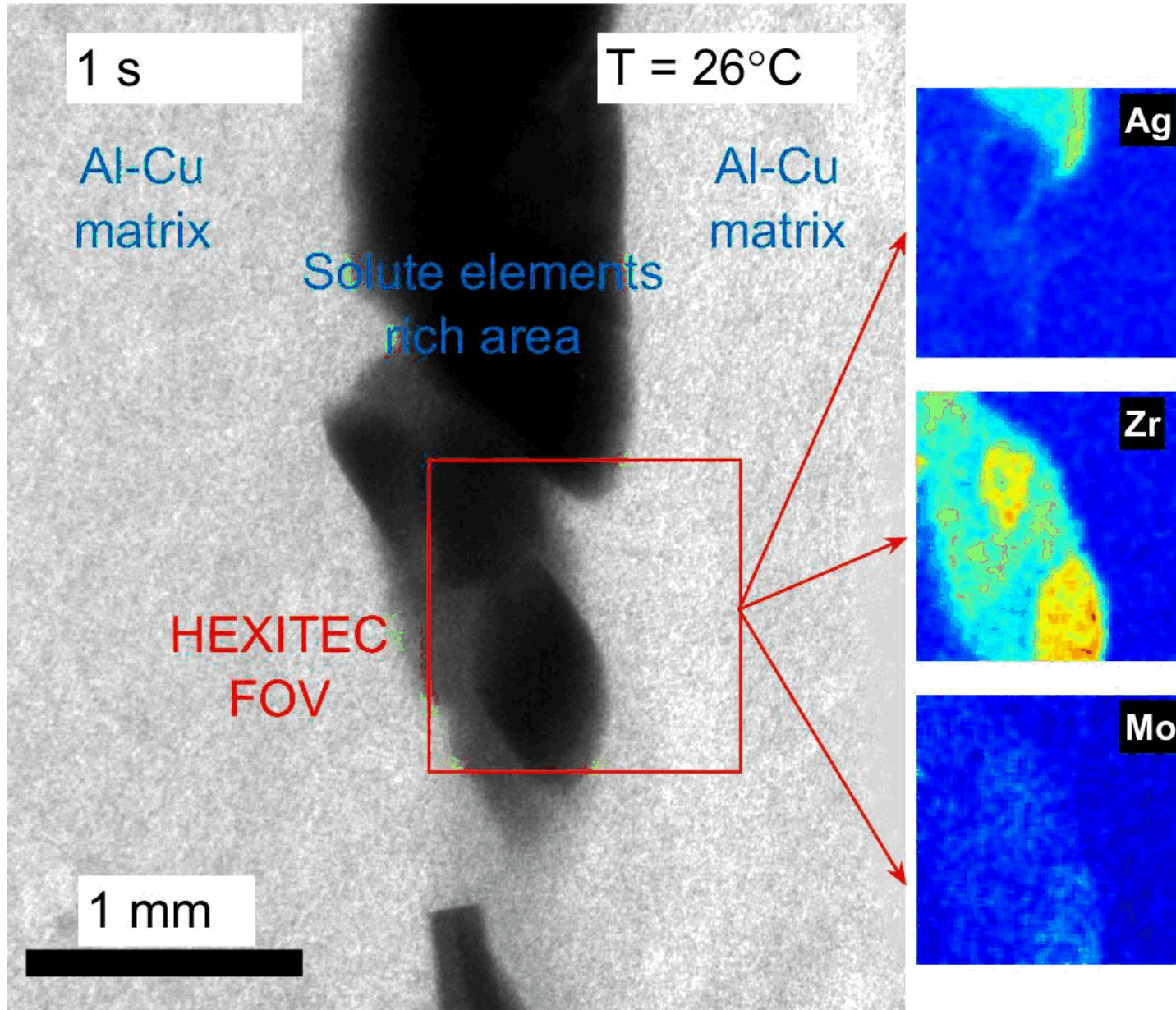


(d)



(e)

Dynamic XRF Imaging





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Where Next???

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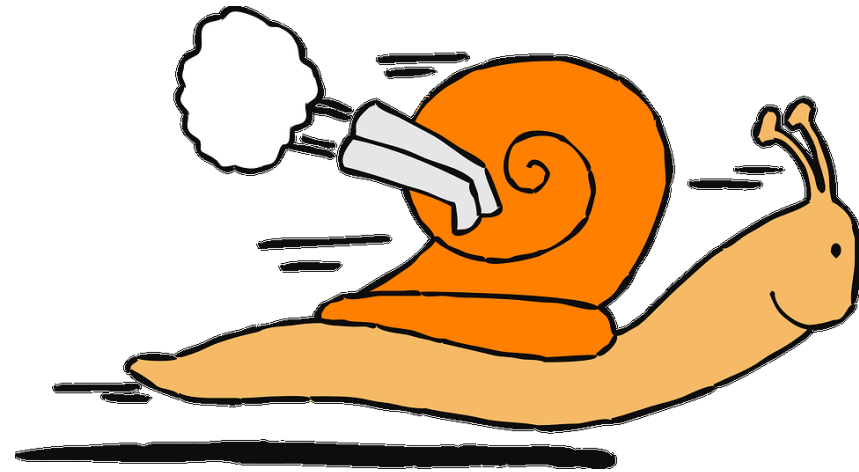
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HEXITEC Developments

- Going faster!
- April 2018: new chip design.
- Aiming for $\times 10$ increase in rate.
- $>1 \times 10^5 \text{ ph s}^{-1} \text{ mm}^{-2}$
- Better charge sharing identification.
- Relatively easy to implement...





Higher Rates

Higher Energy

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Thank You For Listening!