Australian Government

ANSTO

High Energy Capabilities
+
Cultural Heritage at XFM

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Science. Ingenuity. Sustainability.

Techniques for Cultural Heritage Analysis Should Be:

Non-destructive (non-invasive)	Samples are often rare & unique items
Fast & Universal	Different object types with minimal or no sample pre-treatment
Versatile	Allow local information of small areas and average composition to be obtained (spatial resolution)
Multi-elemental/ component	Simultaneously detect multiple components in a single measurement
Sensitive	Able to detect trace quantities

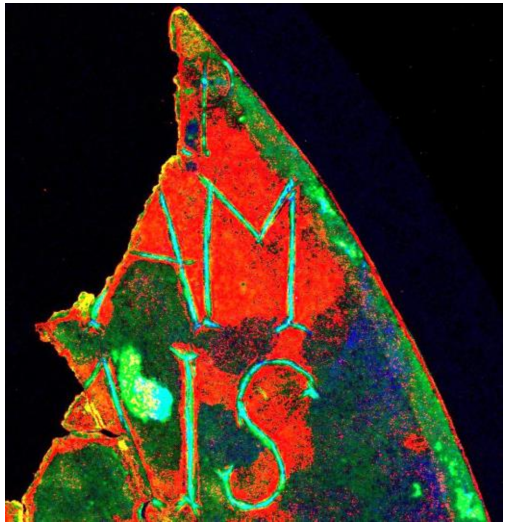
XFM usually satisfies these requirements

Cultural Heritage materials studied at XFM

- Paintings, drawings (most common)
- Aboriginal artefacts
- Rock art
- Metallic objects
- Books (500 year old incunable)
- Paint samples (e.g. van Gogh)
- Ancient Egyptian pottery
- Historic photographs (reclaim lost images)
- Dinosaur fossils (not strictly cultural)
- Arguably, plutonium analysis from the British nuclear testing done in Australia, 1950s

Sydney Bird Painter, 1790s

Hidden Degas portrait, c.1876



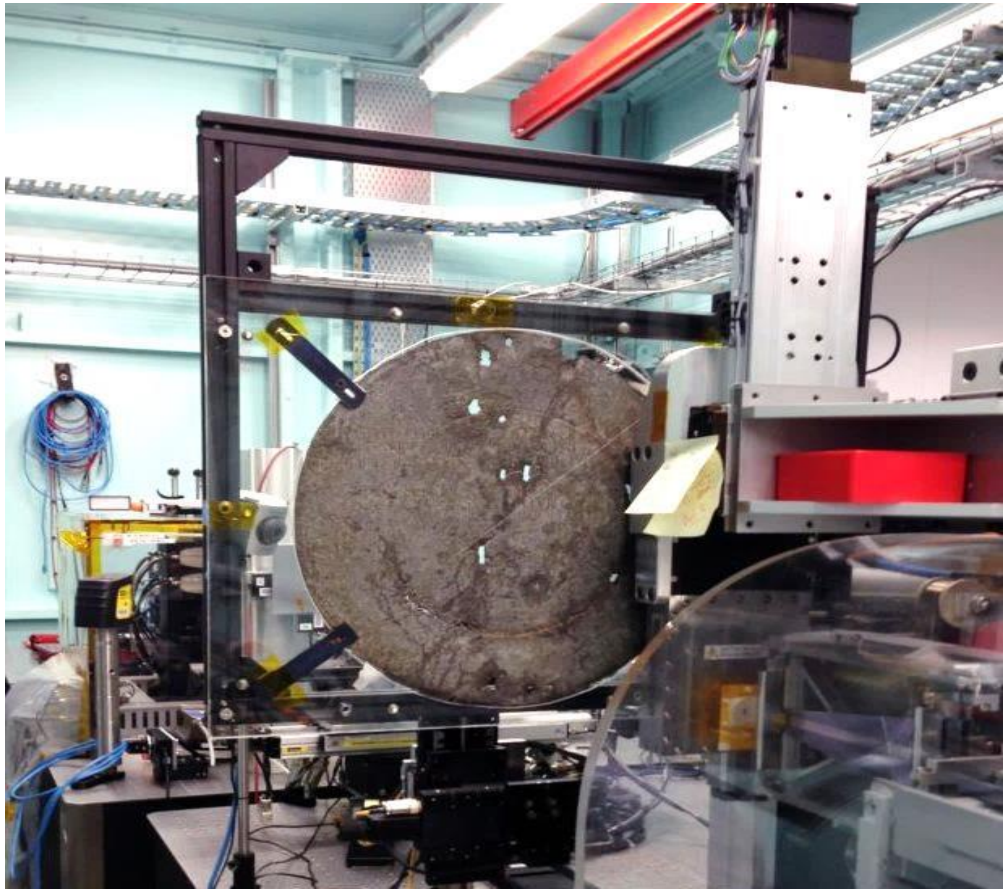
Hartog pewter Plate, 1616

de Vlamingh 1697 Pewter Plate

DR IAN MACLEOD, WA MARITIME MUSEUM

Pewter plate, 32 cm diameter

Western Australian Maritime Museum

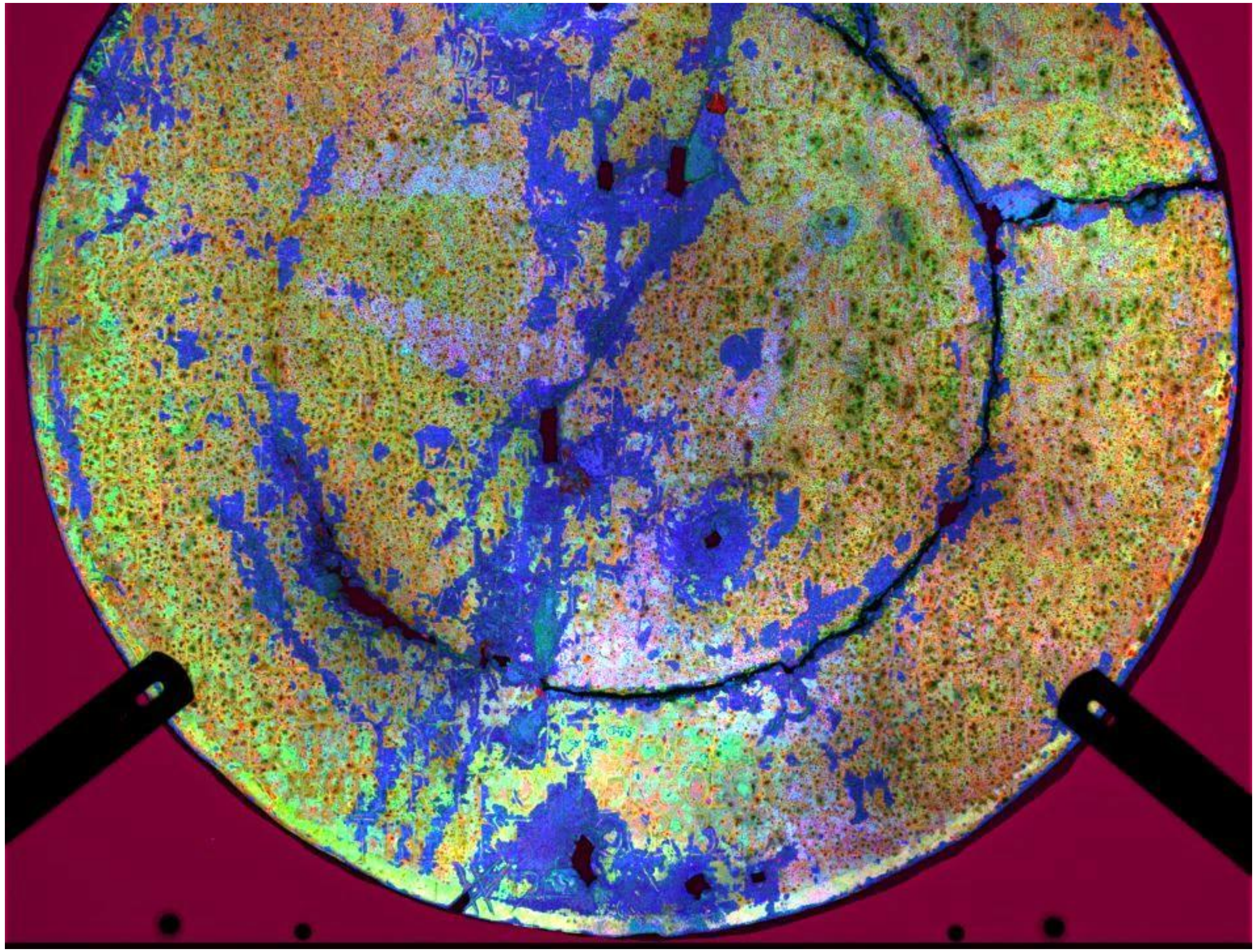


Custom-made mount

MacLeod, I.D, et al. In **ICOM-CC 17th Triennial Conference Preprints, Melbourne,** September 2014, ed. J. Bridgland, art. 0903, 6 pp. Paris: International Council of Museums

de Vlamingh 1697 Pewter Plate

DR IAN MACLEOD, WA MARITIME MUSEUM



False colour image

Zn : Pb : Cu

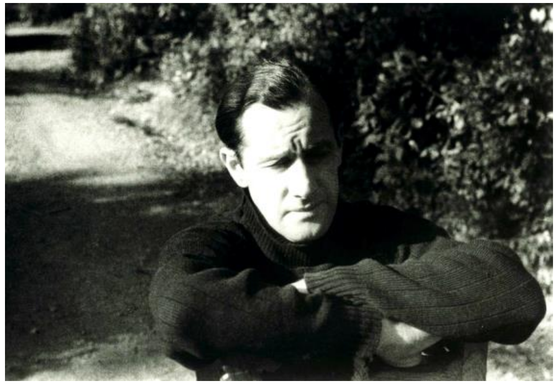
18.5 keV, 100 micron pixels
6 ms dwell

Detailed corrosion history

MacLeod, I.D, et al. In **ICOM-CC 17th Triennial Conference Preprints, Melbourne,** September 2014, ed. J. Bridgland, art. 0903, 6 pp. Paris: International Council of Museums

Sidney Nolan (Australian, 1917-1992)

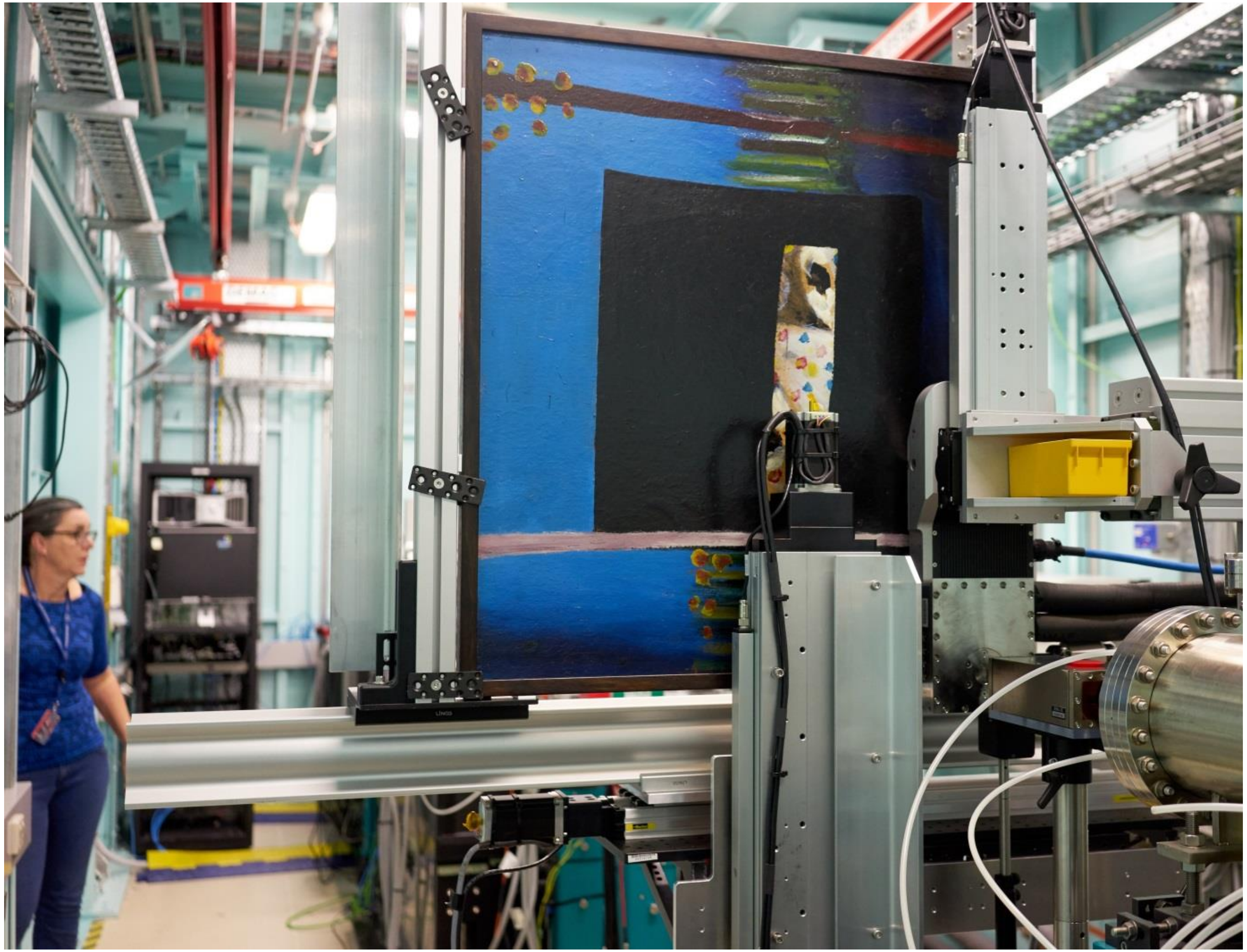
Sidney Nolan *Ned Kelly* (1946)
National Gallery of Australia



Sidney Nolan 1940s
photo: Albert Tucker

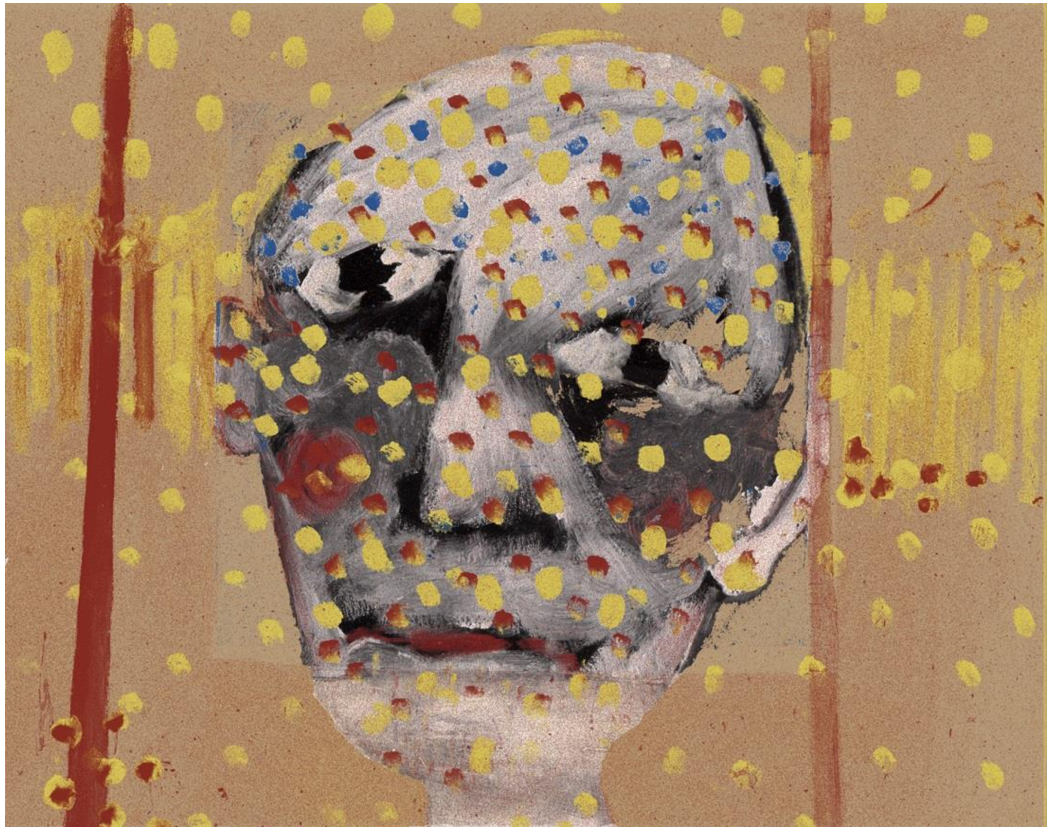
Ned Kelly
Australian outlaw
c. 1870s
State Library of Victoria

Sidney Nolan (Australian, 1917-1992)



Sidney Nolan,
Ned Kelly: 'Nobody knows anything about my case but myself'
1945, enamel **on cardboard**, 64 x 76 cm,
Heide Museum of Modern Art,
Purchased with funds provided by
the Friends of the Museum of Modern Art
at Heide and the Heide Circle of Donors 1998

Sidney Nolan



Ba – red
Pb/Cr – yellow
Zn – white
Cu/Fe – blue

100 micron pixel, 35 mm/s scan speed, 2.9 ms dwell, 18.5 keV

P. Dredge et al.: Unmasking Sidney Nolan's Ned Kelly: X-ray Fluorescence Conservation Imaging, Art Historical Interpretation and Virtual Reality Visualisation. Aust. New Zeal. J. Art. **17**, 147–161 (2018)

Large area scanner - Milliprobe

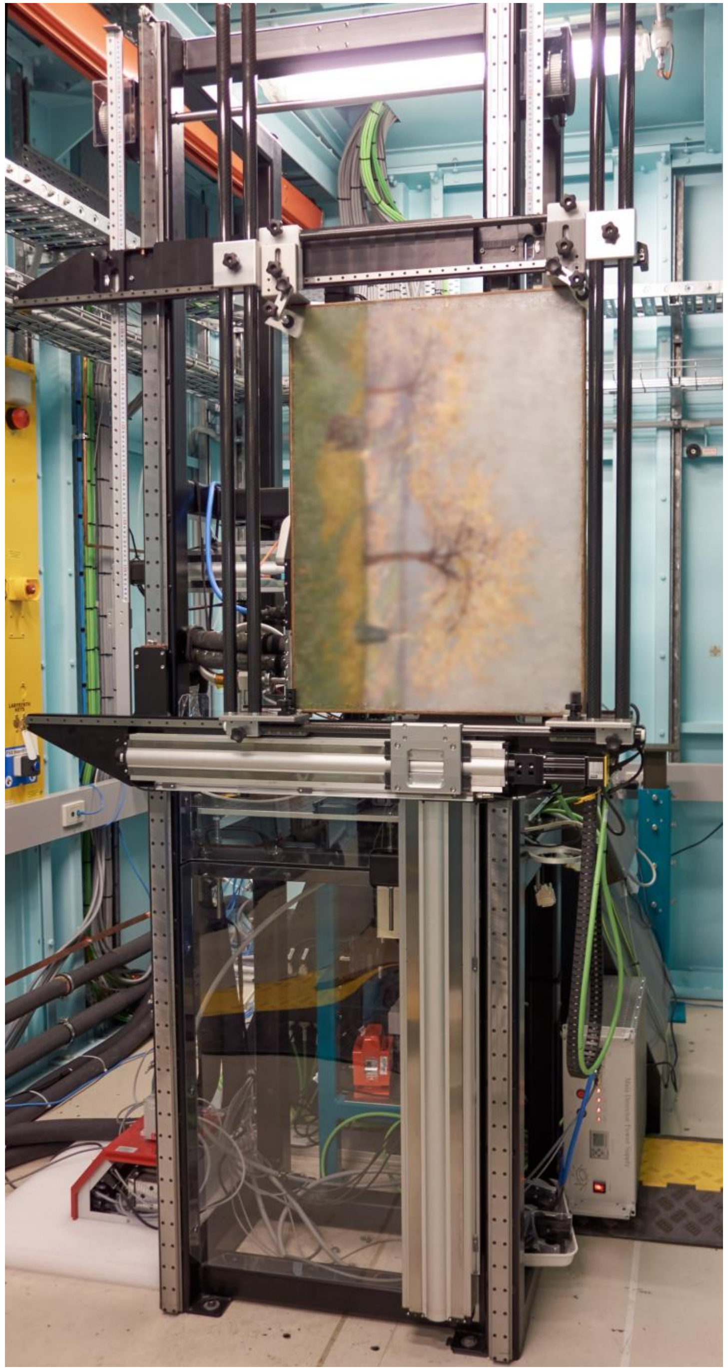
Technical Specifications

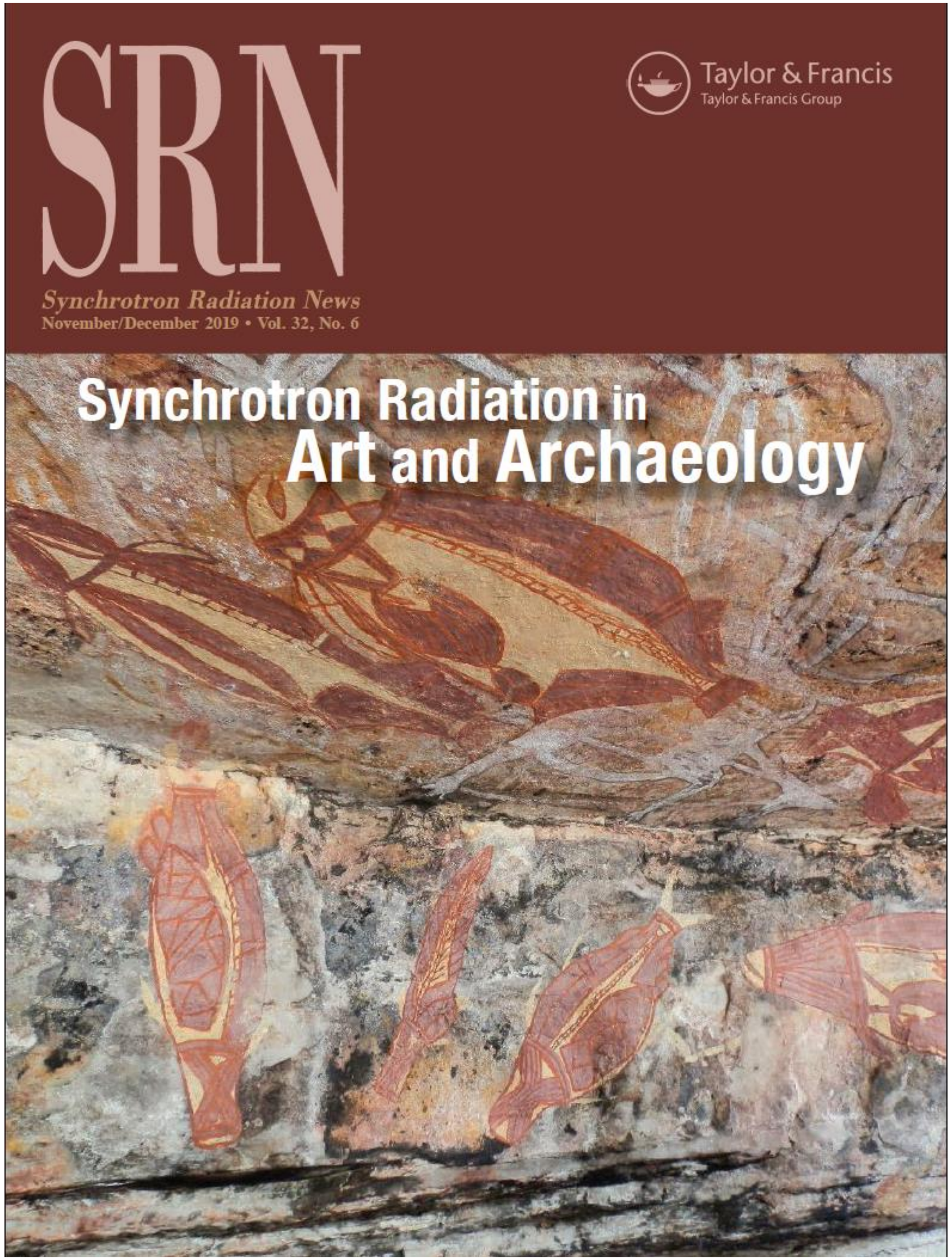
X axis: 600 mm travel
Y axis: 1100 mm travel

Scanning Speed of X stage: Up to 175 mm / s

Max. sample size:
1250 (H) × 1750 (W) × 60 mm thick.
Scan range is limited when approaching max. sample size.

Maximum weight of sample: 15 kg.





For more information:
Synchrotron Radiation News, Nov/Dec vol. 32 (2019)

Research in Art and Archaeology: Capabilities and Investigations at the Australian Synchrotron

H. E. A. Brand,[1] D. L. Howard,[1] J. Huntley,[2] P. Kappen,[1] A. Maksimenko,[1] D. J. Paterson,[1] L. Puskar,[3] and M. Tobin[1]

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Higher Energy Capabilities at XFM

Traditionally XFM's maximum incident energy was 18.5 keV.
(e.g. up to Zr K-edge)

Now we can go to 27.2 keV

access element K-edges of

Nb, Mo, Tc, Ru, Rh, Pd, Ag, Cd

(difficult to detect their L lines)

Higher Energy Capabilities at XFM

Some downsides:

- Less flux at higher energy
- Less sensitive detection of lighter elements (lower cross section)
- Silicon-based detectors are inefficient at high energy

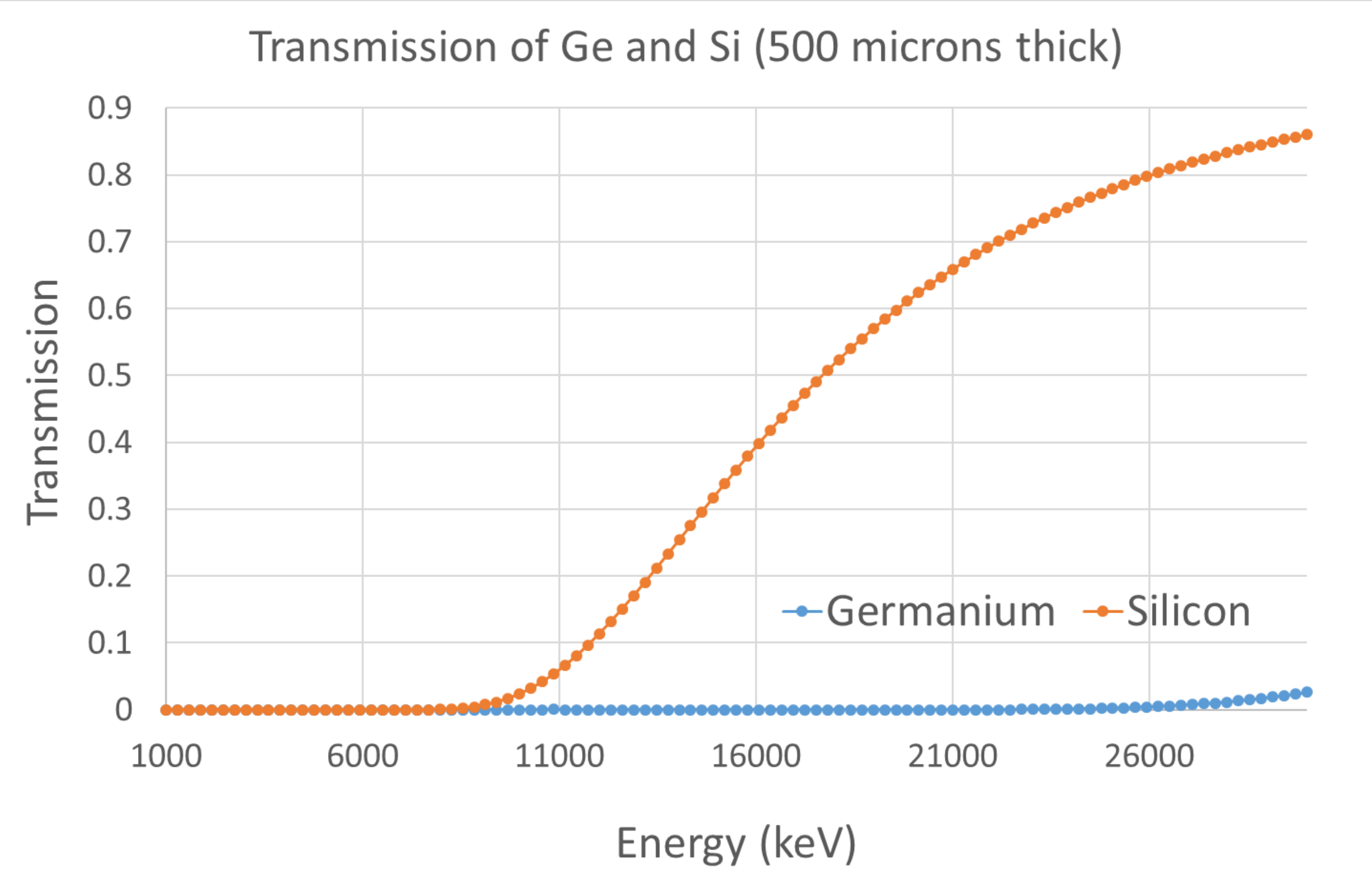
→ slower data collection

Some upsides:

- Double multilayer monochromator (DMM) is coming - 10x more flux
- We plan to purchase a Germanium detector

→ faster data collection

Detector Sensor Type Efficiency



More efficient Ge detector (~160× at 26 keV) is on our wish list.

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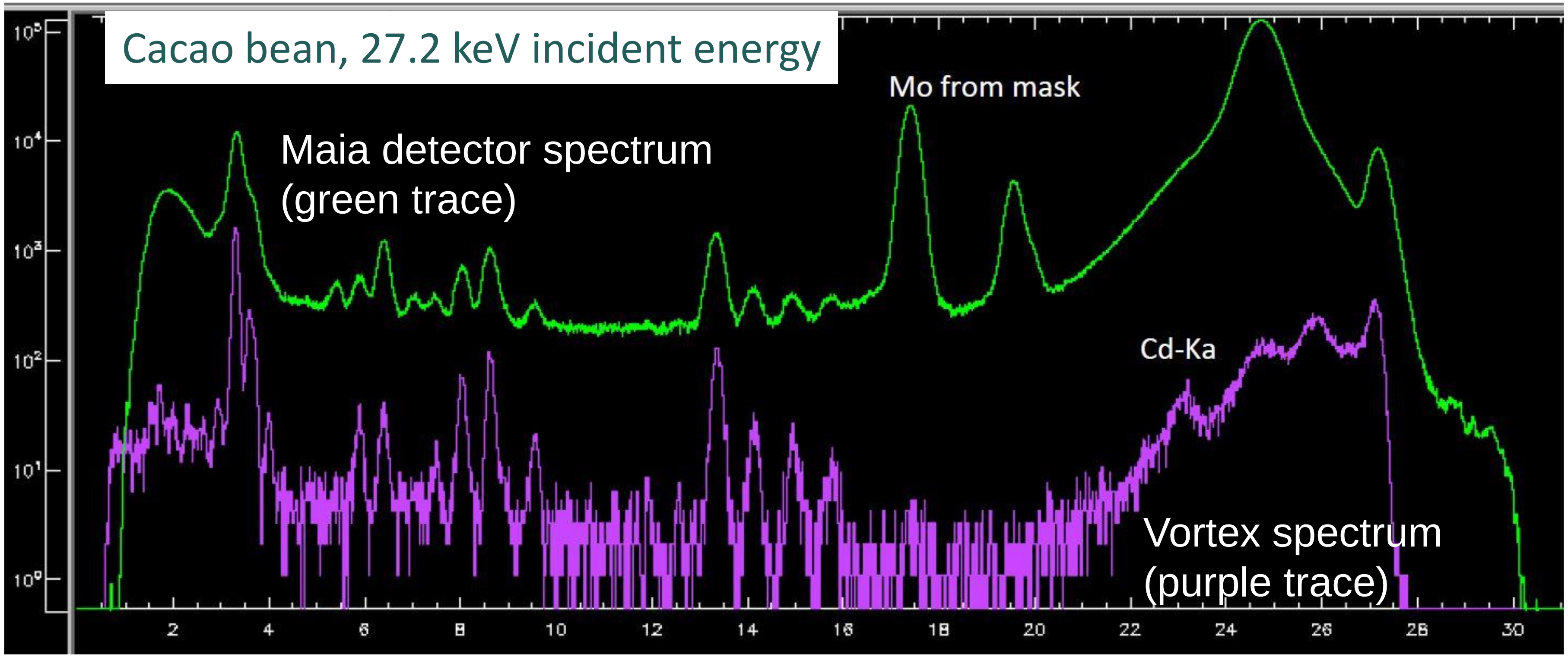
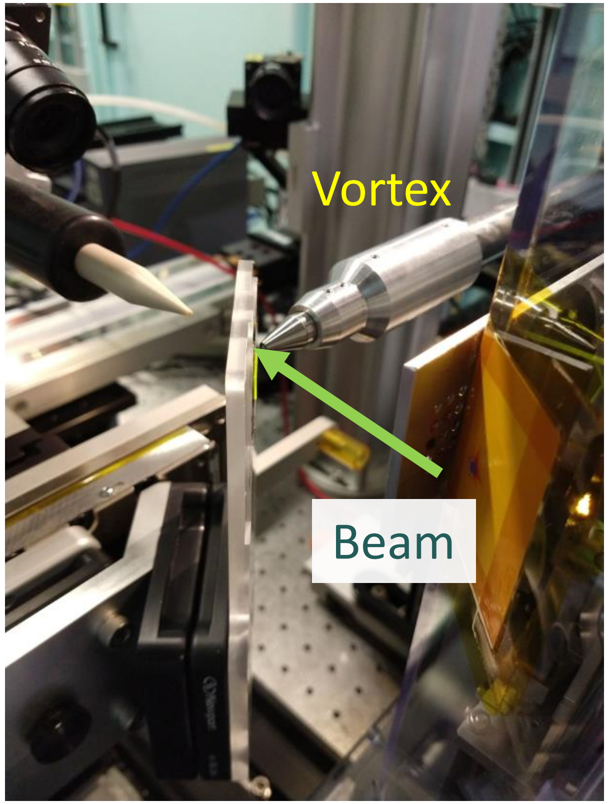
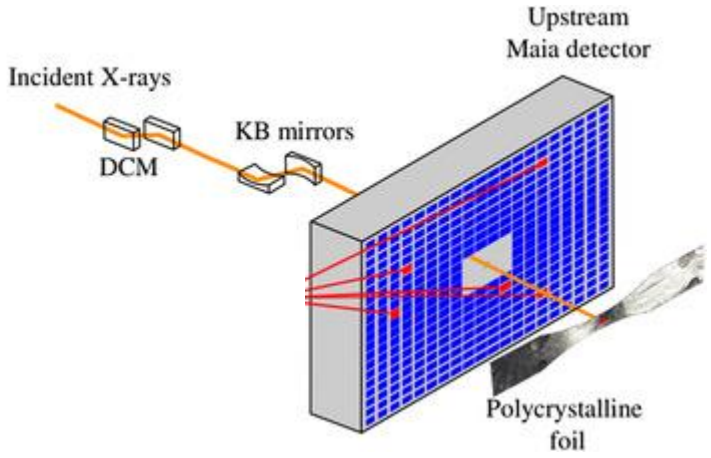
Higher Energy Capabilities at XFM



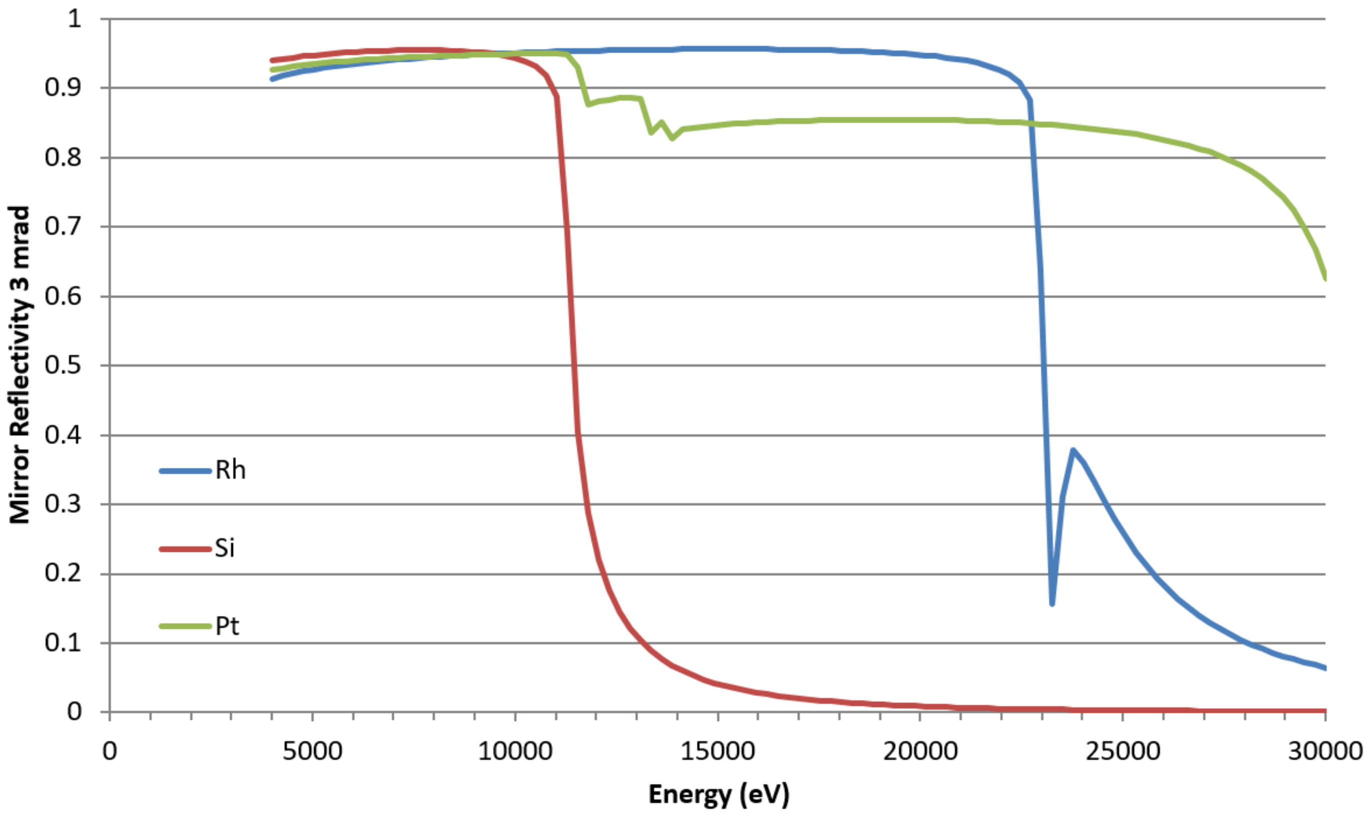


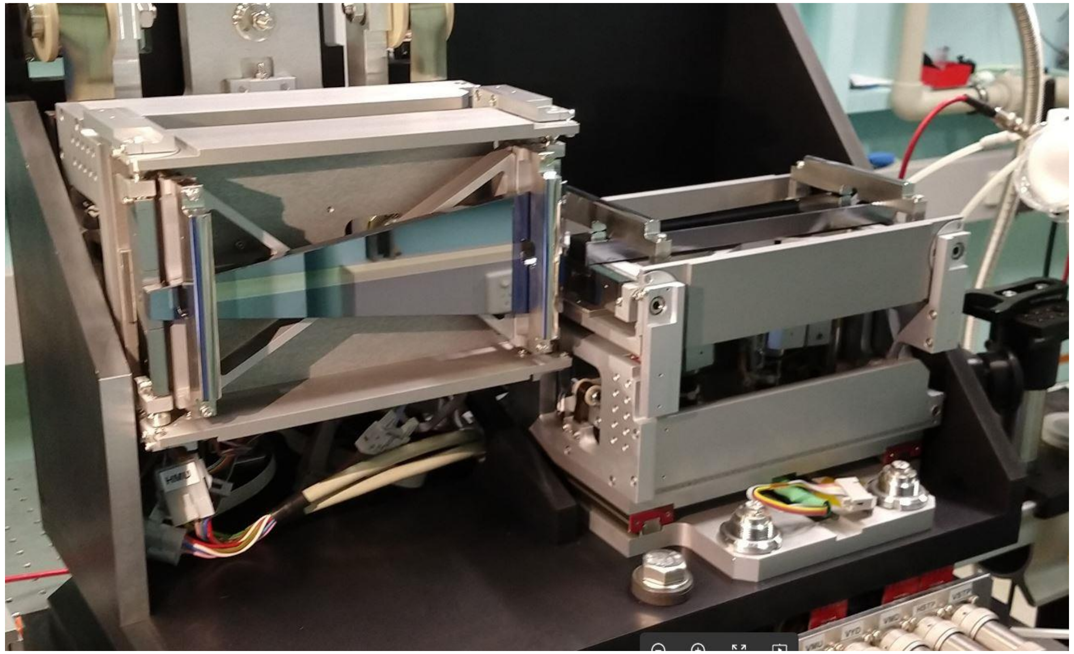
Vortex detector orthogonal to beam minimises scatter.



Maia detector in backscatter geometry.

Mirror coating reflectivities



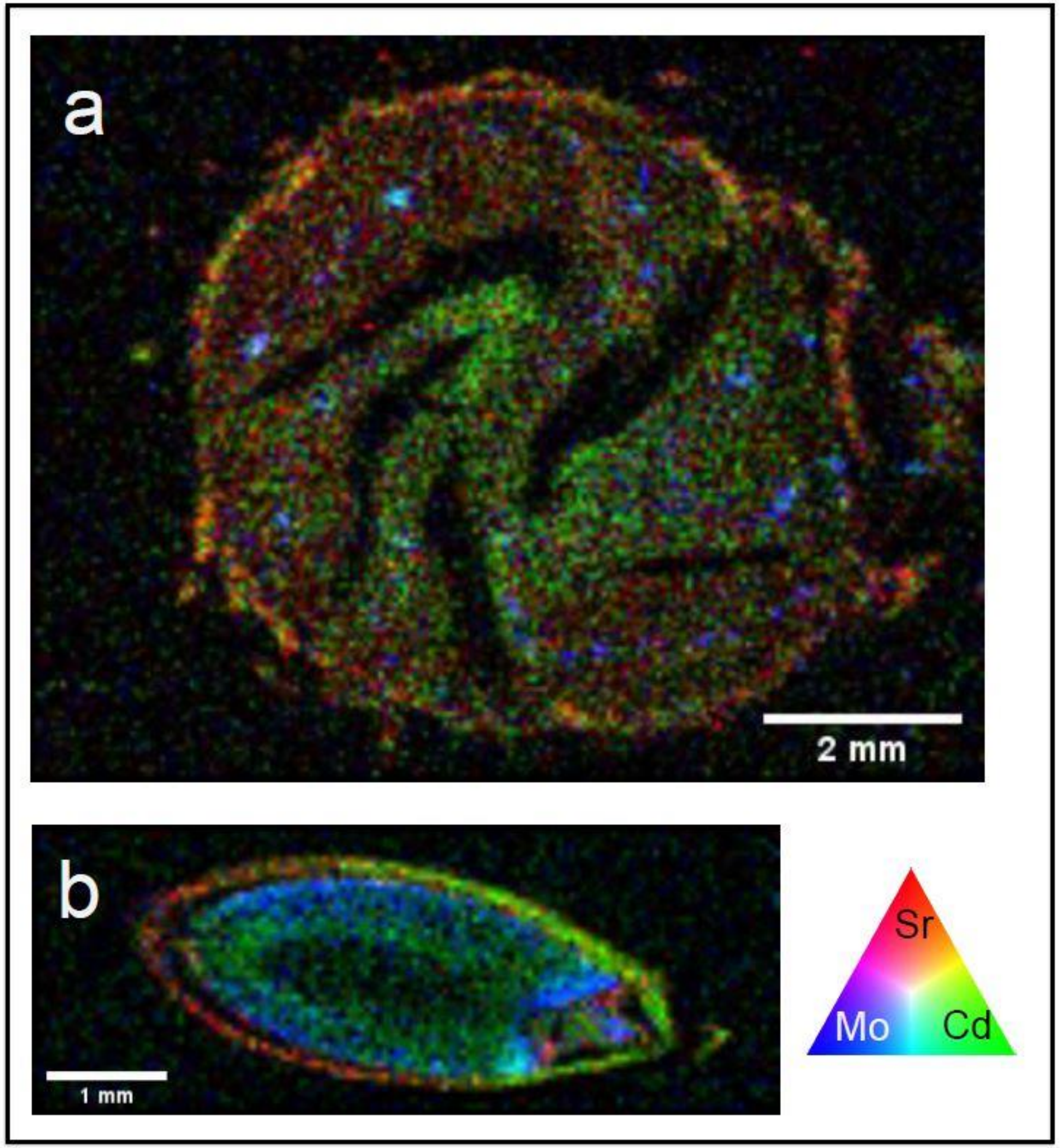


KB mirrors

Our mirrors were 'stuck' on Rhodium stripe.

Had to use unfocussed beam, defined by slits.

Higher Energy Capabilities at XFM



a) cacao bean section, 100 micron thick.

b) rice grain section, 100 micron thick.

XFM maps recorded at **27.2 keV** incident energy with **unfocused beam** and single element **Vortex detector**.

1 sec dwell per **50 micron** pixel.

Cd minimum detection limit ~1 ppm.

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XFM User Wiki page

https://asuserwiki.atlassian.net/wiki/spaces/UO/pages/22609927/XFM+Beamline

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