

COSCH STSM WG1: Elaboration of Hyperspectral Image Data from Round Robin Test Acquisition

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Centre for Doctoral Training*

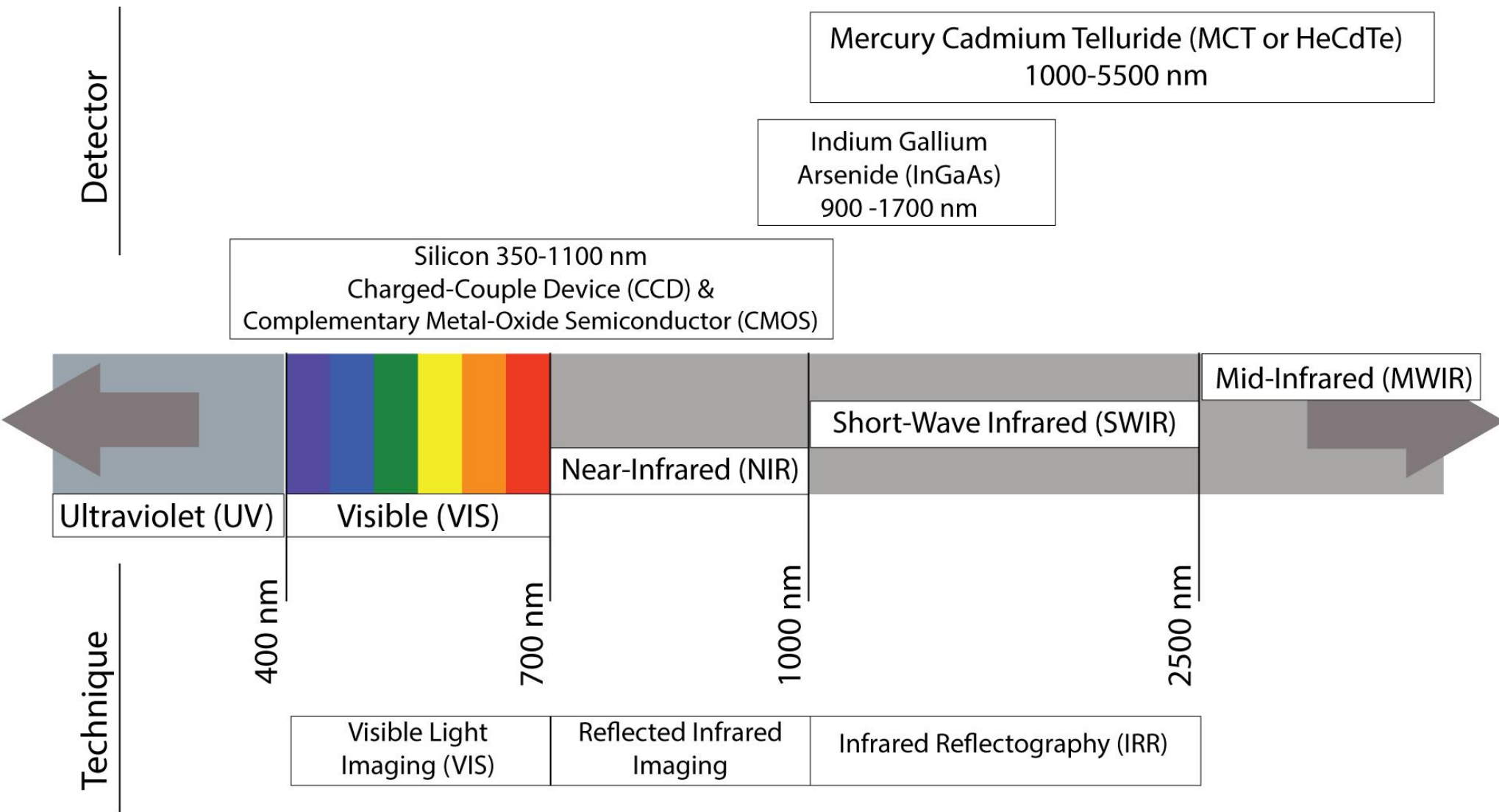
April 2015

Host: Marcello Picollo

Instituto di Fisica Applicata “Nello Carrara”—Consiglio
Nazionale delle Ricerche (IFAC-CNR)

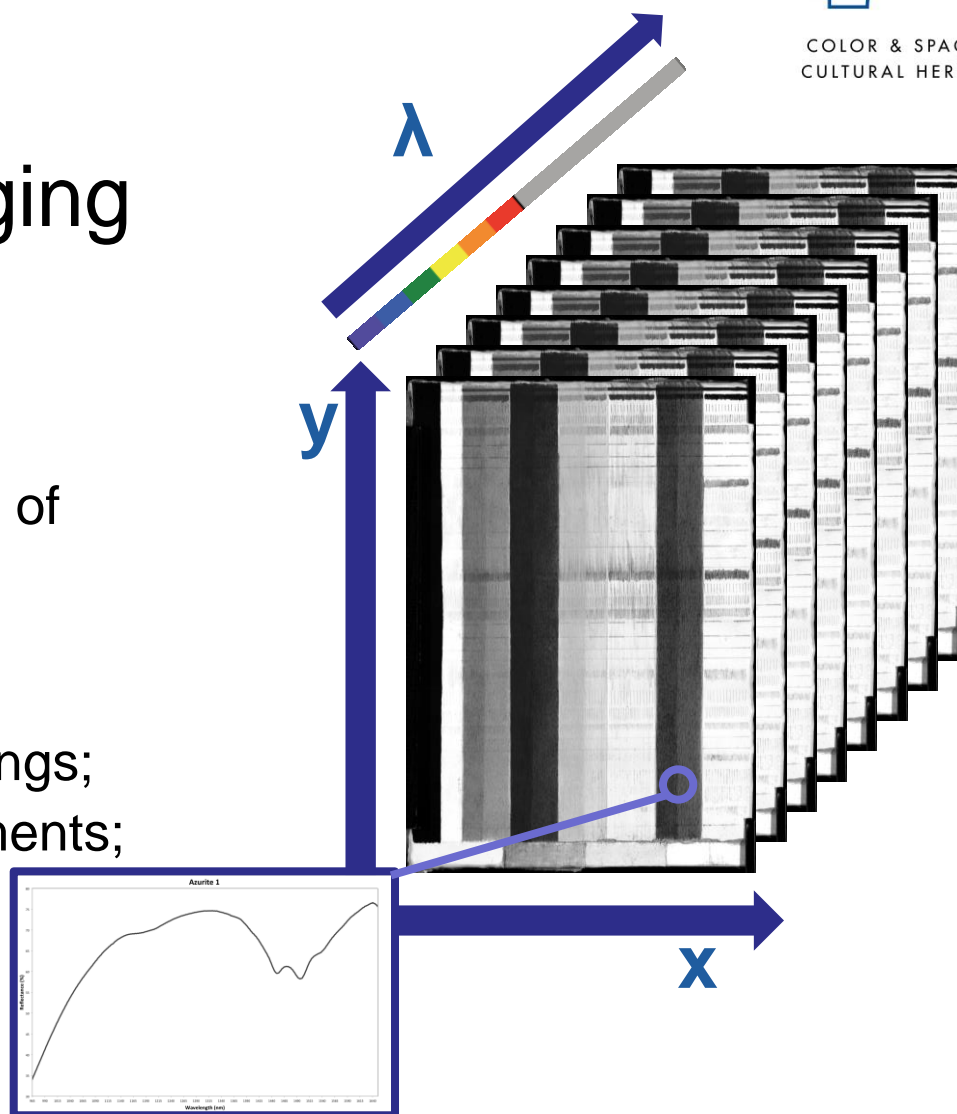
Florence, Italy

Infrared (IR) Techniques & Technologies



Imaging Spectroscopy

- Combining digital imaging and spectroscopy¹
 - Expands point-based, or 1D, spectroscopic techniques
 - Ability to map spatial distribution of materials over entire object;
 - Extract reflectance spectra for identification of materials;
 - Enhance and reveal underdrawings;
 - Identify past conservation treatments; and
 - Measure colour (only in VIS).



1. Liang, H., 2012. Advances in multispectral and hyperspectral imaging for archaeology and art conservation. *Applied Physics A* (2012) 106: pp309-323.

Imaging Spectroscopy

Multispectral Imaging²

- Sequence of images with bandwidths of tens to hundreds of nanometers

Hyperspectral Imaging²

- Sequence of images with bandwidths of a few nanometers or less

2. Riccardi et al. 2013. Use of imaging spectroscopy and in situ analytical methods for the characterization of the materials and techniques of 15th century illuminated manuscripts. *Journal of the American Institute for Conservation*. 2013 (52), 13-29.

Round Robin Test (RRT): Objectives

- To work towards standardised methodologies and best practices for spectral imaging in the CH field
- To better understand:
 - instrumentation
 - elements of data acquisition
 - the effects of the instruments and methodology to the accuracy and reliability of the data

Round Robin Test (RRT): Materials



Figure from Vitorino

SphereOptics Zenith Polymer Wavelength Standard

X-Rite White Balance

X-Rite ColorChecker® CLASSIC

Painted test panel –medieval Tuscan technique

Antique Russian Icon (1899) on Copper plate

Round Robin Test (RRT): Materials

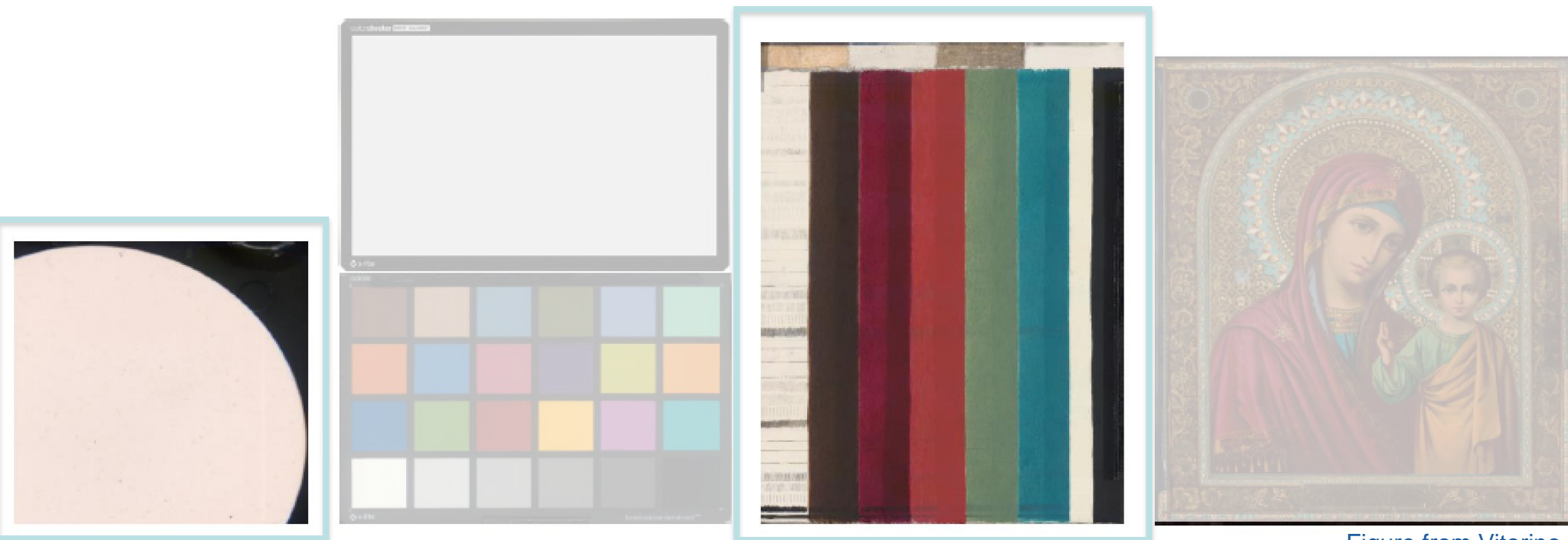


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Painted test panel –medieval Tuscan technique

Antique Russian Icon (1899) on Copper plate

STSM Objectives

- Process and compare RRT data from three institutions acquired in the short-wave infrared (SWIR) region (1000-2500 nm)
- Assess spatial and spectral resolution and how this influences the accuracy and reliability of the resulting data
 - Spatial Resolution—measure of a system's ability to resolve the desired details in the image of an object
 - Spectral Resolution—how well the system can resolve the spectral details
- Inform the standardisation of methodologies and the development of best practices

Test Panel & Underdrawing Materials

Made by Elena Prandi & Marina Ginanni

(Restoration Laboratories of the Polo Museale Toscana)

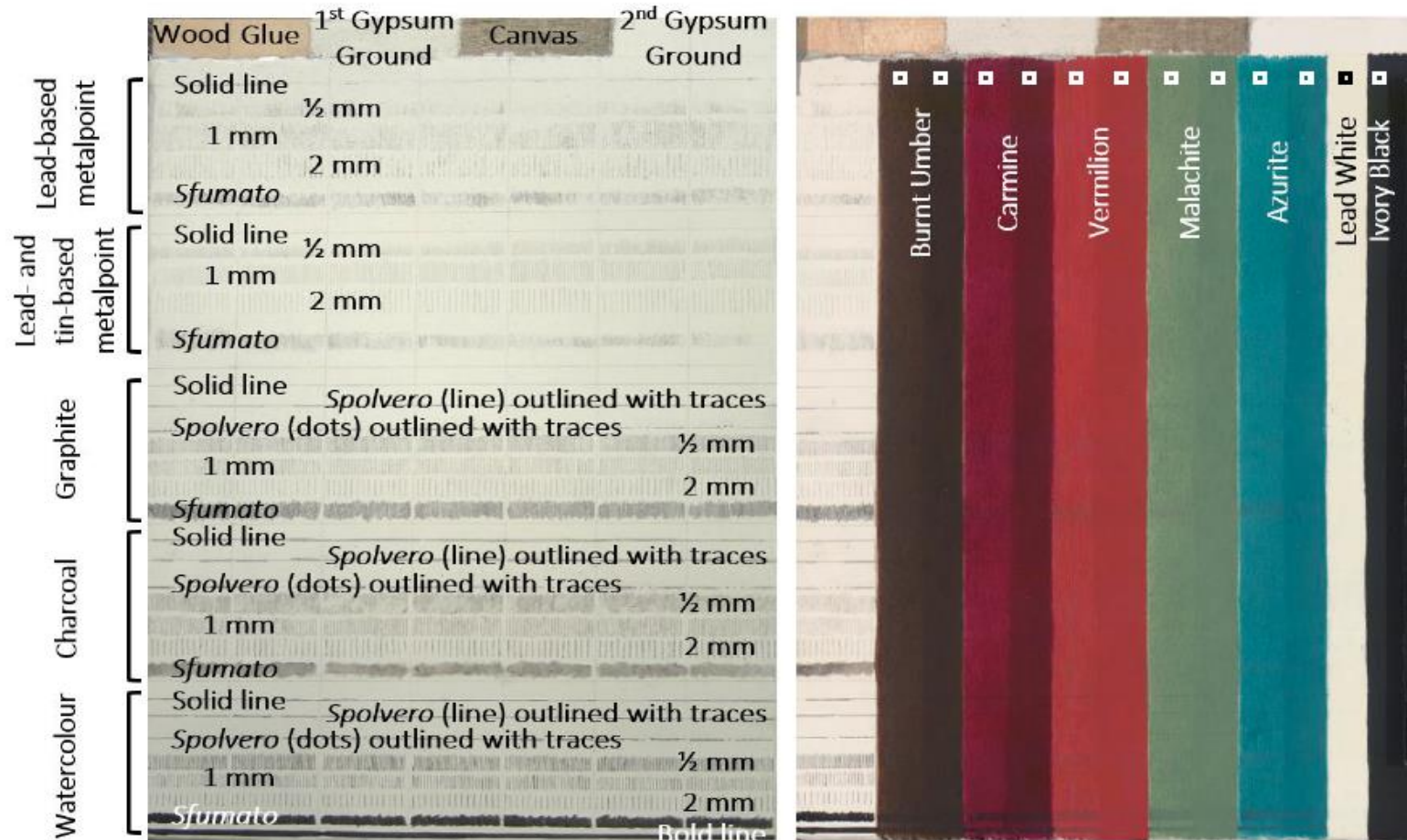
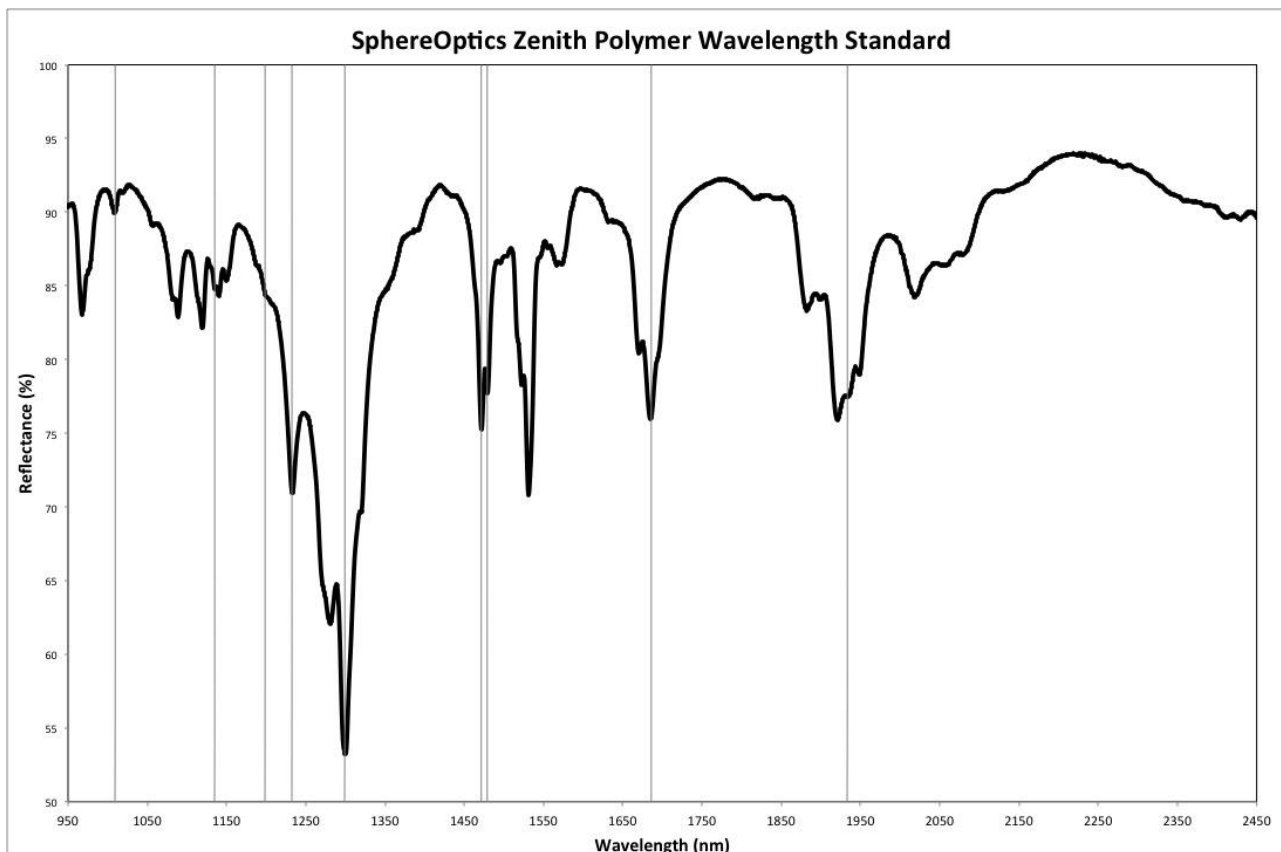


Figure from Vitorino

SphereOptics Zenith Polymer Wavelength Standard

Provided by András Jung (Leipzig University)



Wavelengths include³:

- 1009.5 – 1013.5 nm
- 1134.1 – 1138.1 nm
- 1198.6 – 1202.6 nm
- 1230.5 – 1234.5 nm
- 1299.3 – 1303.3 nm
- 1470.0 – 1474.0 nm
- 1476.0 – 1478.0 nm
- 1682.0 – 1686.0 nm
- 1932.5 – 1936.5 nm



Image from Vitorino

3. Spectralon Wavelength Calibration Standards. [online]. 2015. Available from: <http://www.labsphere.com/uploads/datasheets/wavelength-standards-product-sheet.pdf> [Accessed 11 May 2015]

Data Acquisition: HSI Systems

IFAC-CNR—Istituto di Fisica Applicata “Nello Carrara”—
Consiglio Nazionale delle Ricerche

- Custom-built HSI scanner with ImSpector N17E

NM Krakow—National Museum of Krakow

- Specim ImSpector N25E

UCL-ISH—University College London—Institute for Sustainable
Heritage

- Gilden Photonics HSI system with Specim ImSpector N25E

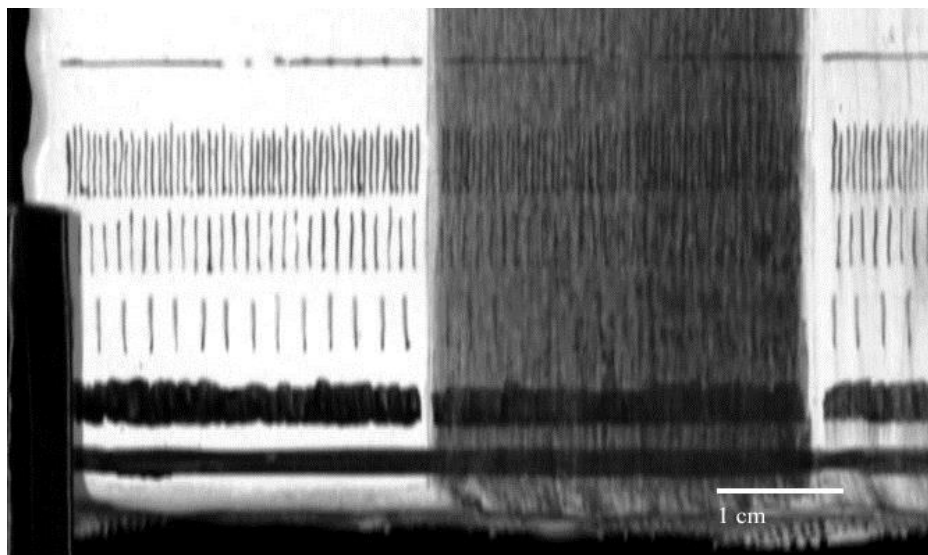
Data Acquisition: HSI Systems

	IFAC-CNR	NM Krakow & UCL-ISH
Spectrophotometer	ImSpector N17E	ImSpector N25E
Sensor Type	InGaAs	MCT
Pixel Dimension (px)	512	320
Spectral Range	900-1700 nm	1000-2500 nm
Spectral Resolution	5 nm	8 nm
Number of Bands	332	256

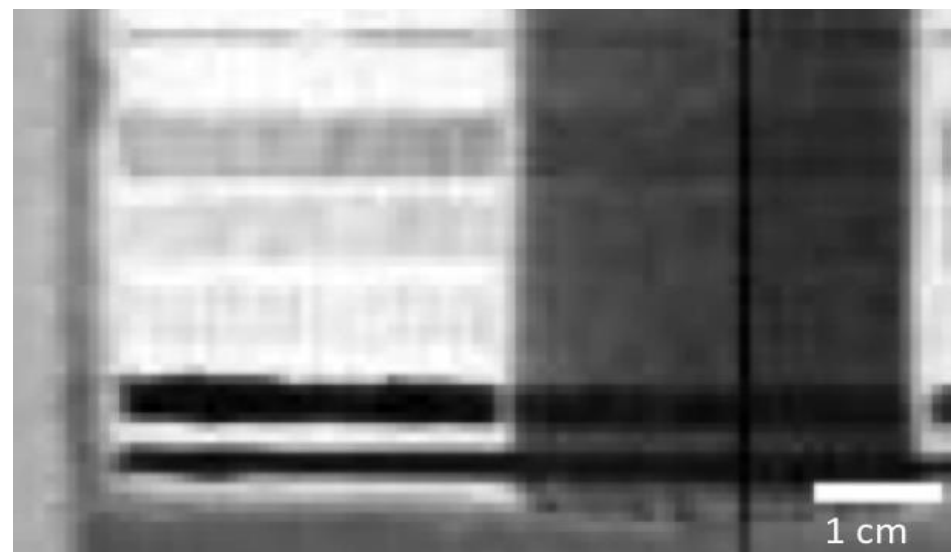
Assessing Spatial Resolution

- Visual comparison
- Plotting vertical profiles
- Calculating the sampling density

Spatial Resolution: Visual Comparison



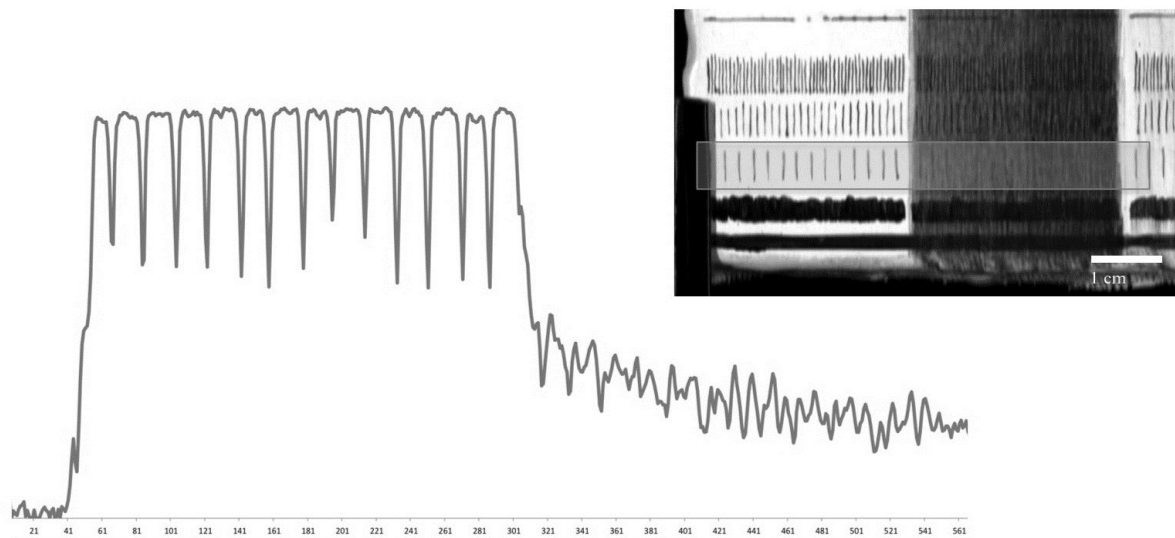
IFAC-CNR



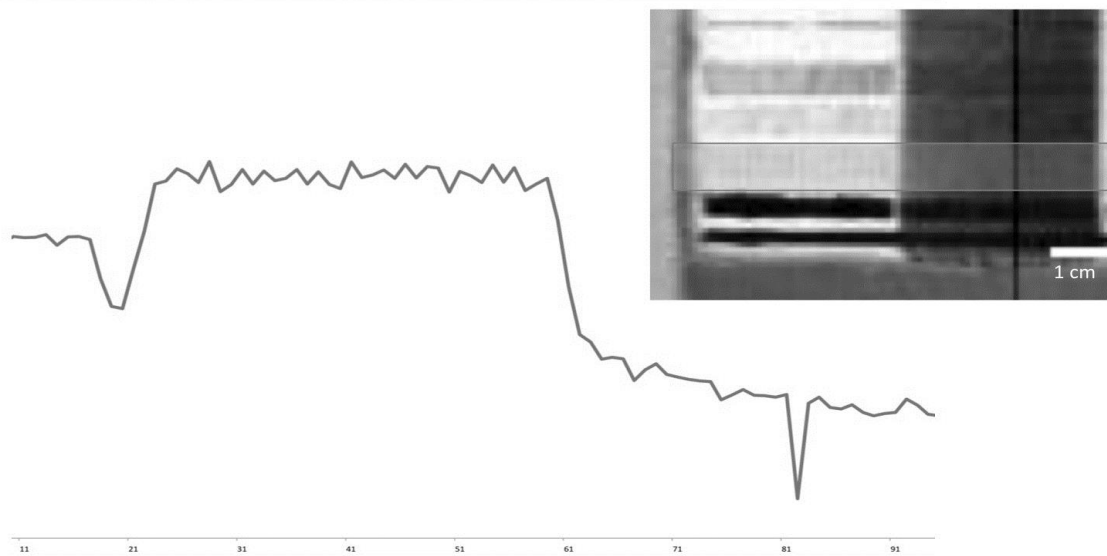
NM Krakow

Spatial Resolution: Vertical Profiles

IFAC-CNR

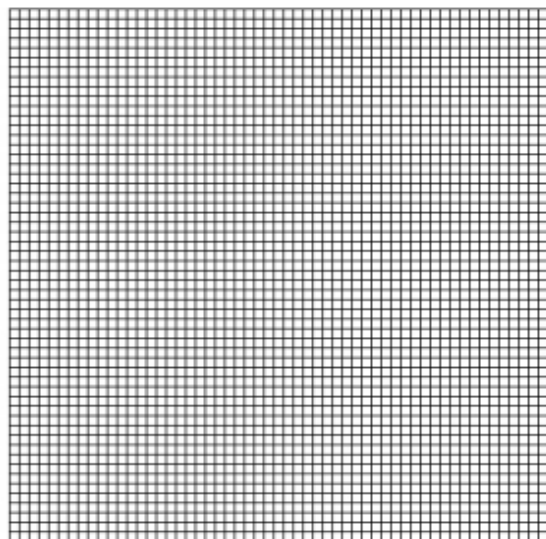


NM Krakow



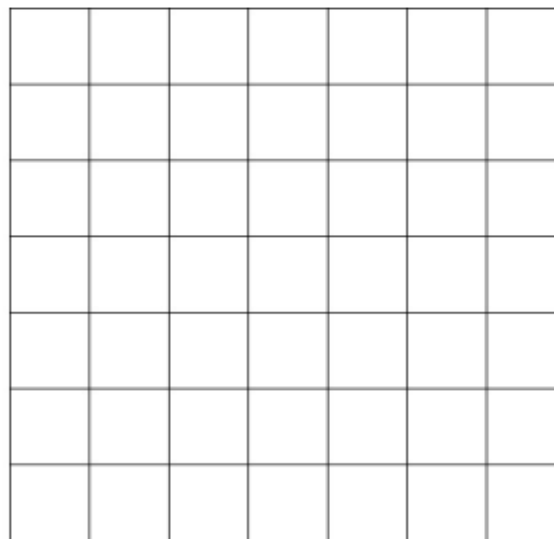
Spatial Resolution: Sampling Density

IFAC-CNR
55 x 55 pixels



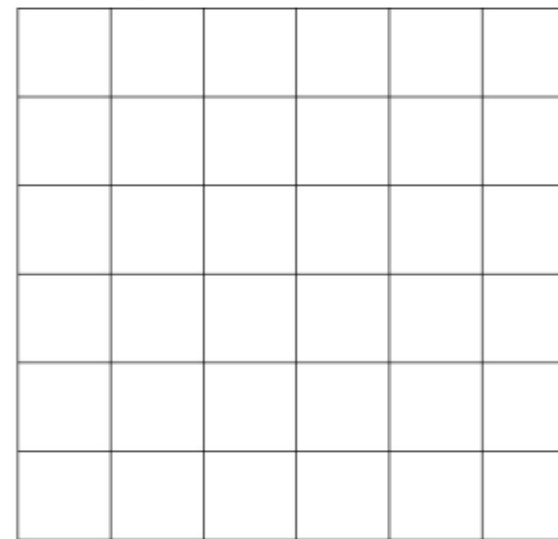
9.12 px/ mm

NM-Krakow
7 x 7 pixels



1.17 px/ mm

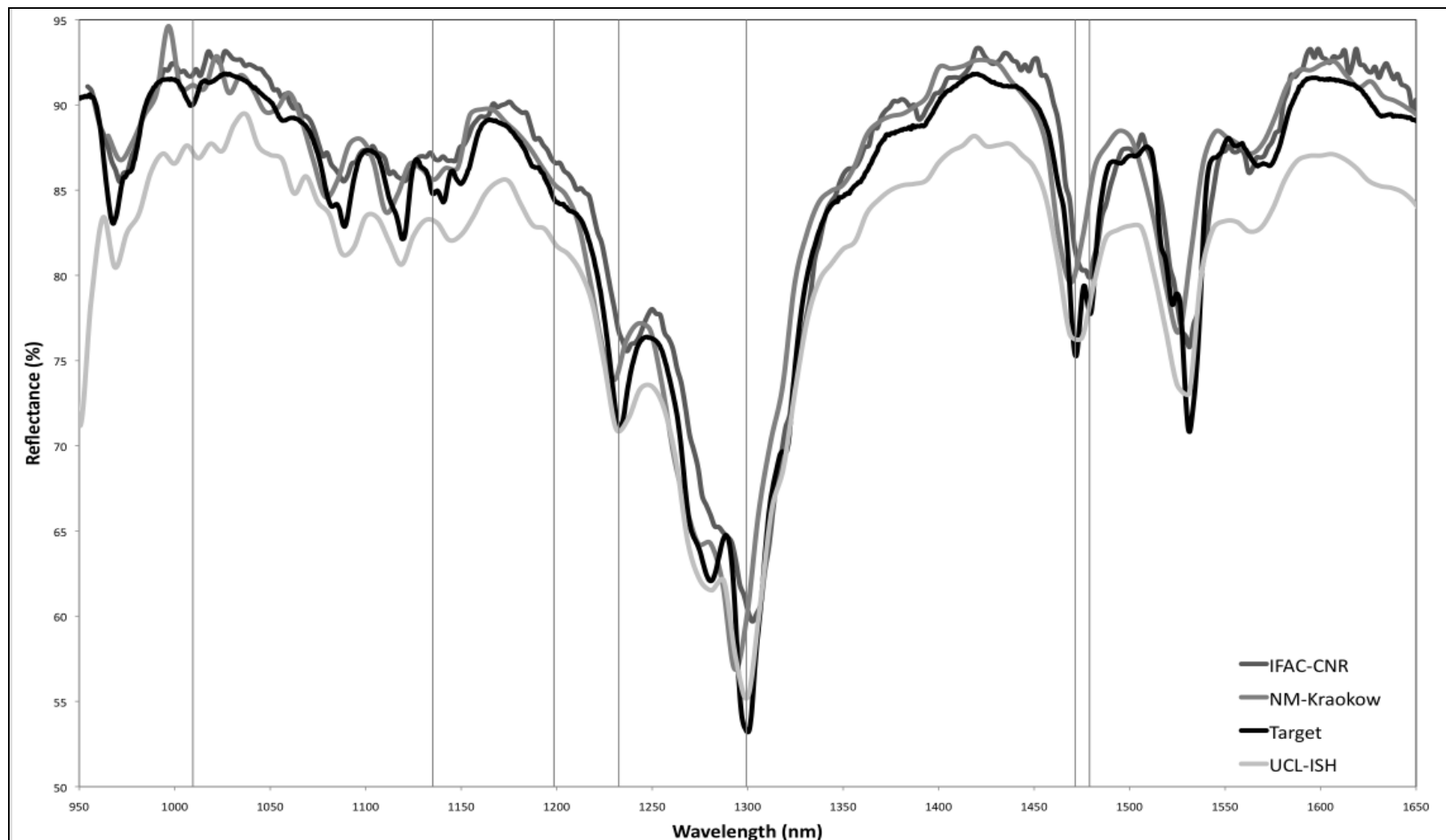
UCL- ISH
6 x 6 pixels



1.05 px/ mm

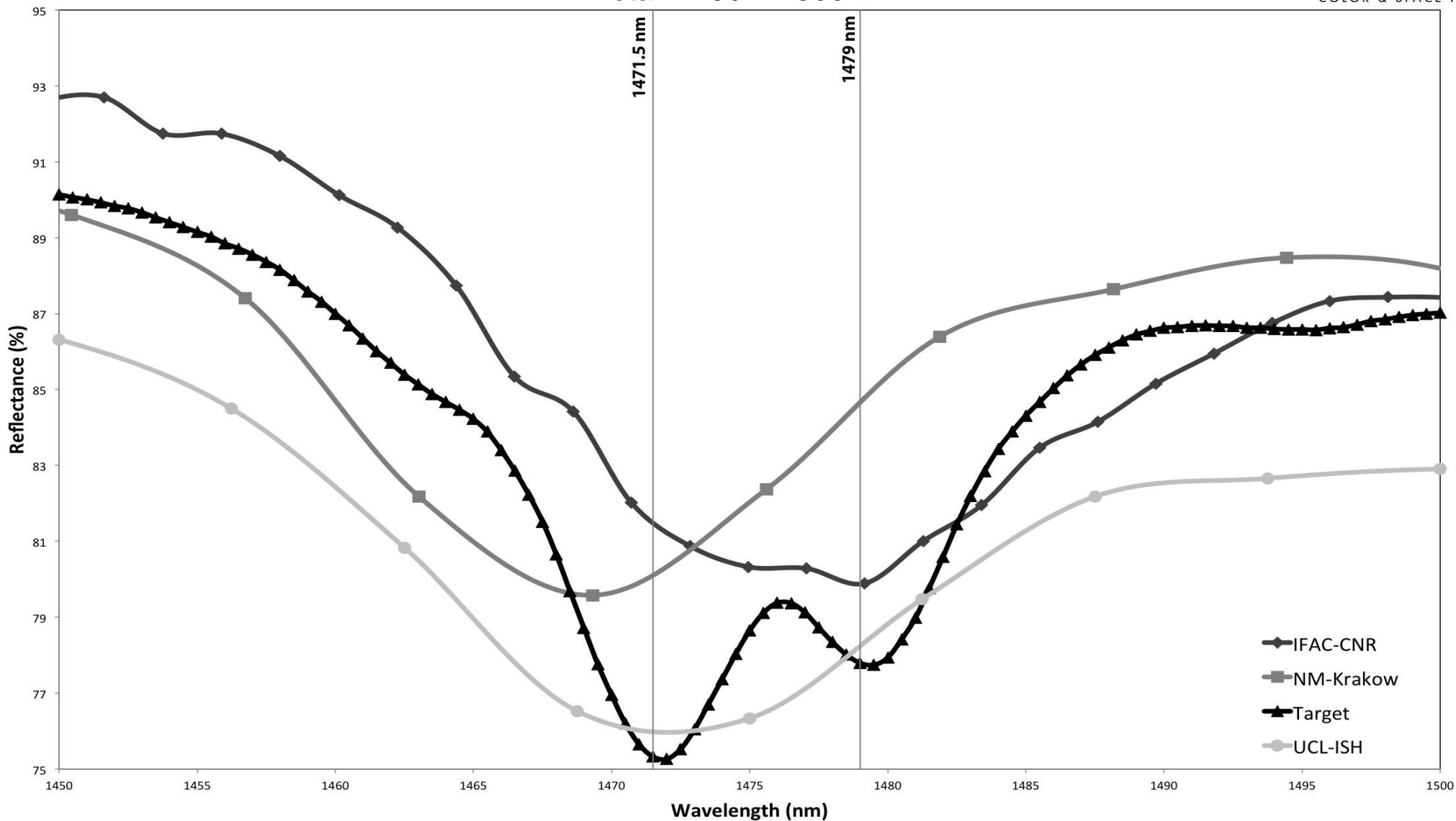
Assessing Spectral Resolution

SphereOptics Zenith Polymer Wavelength Standard

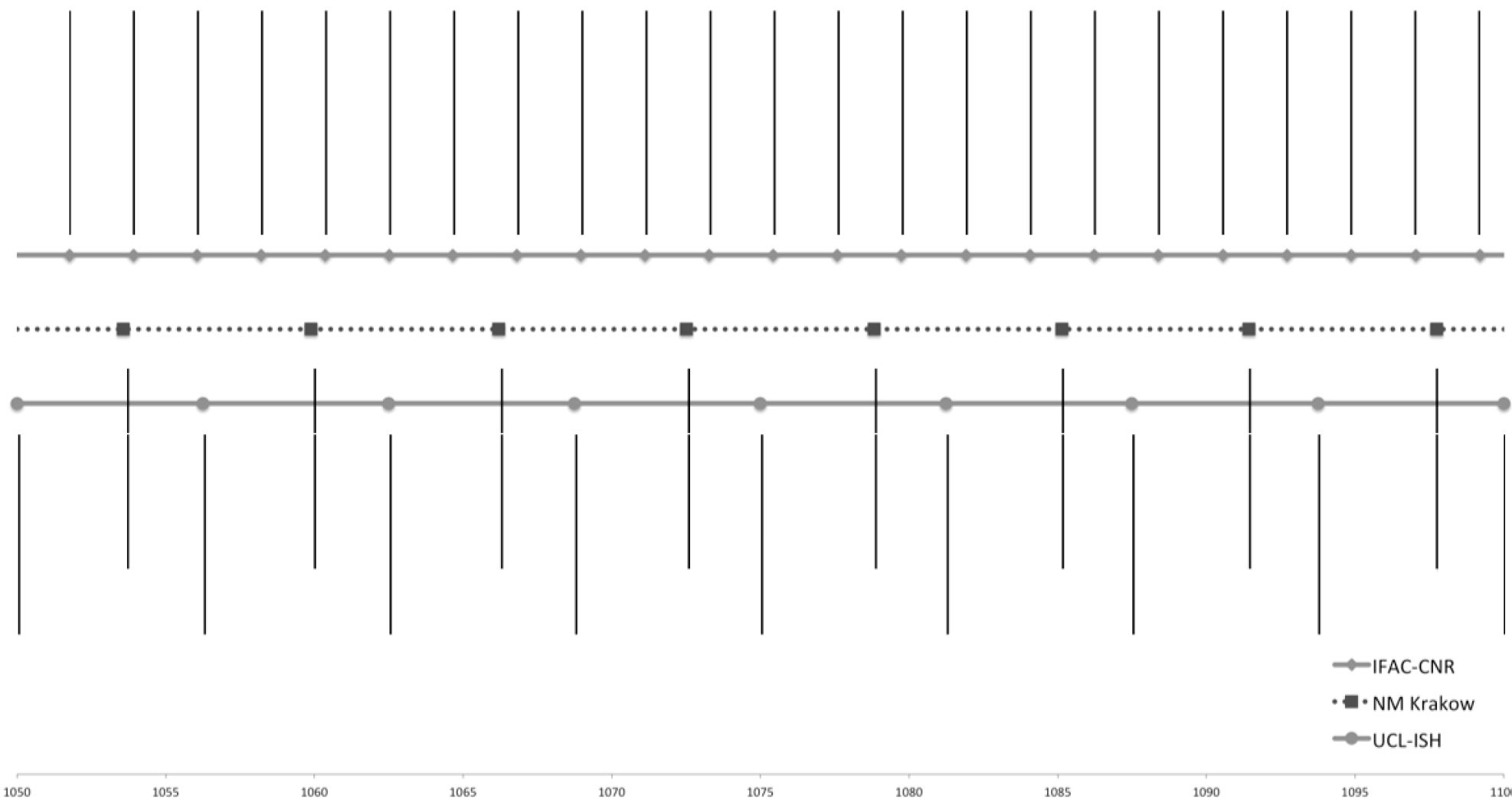


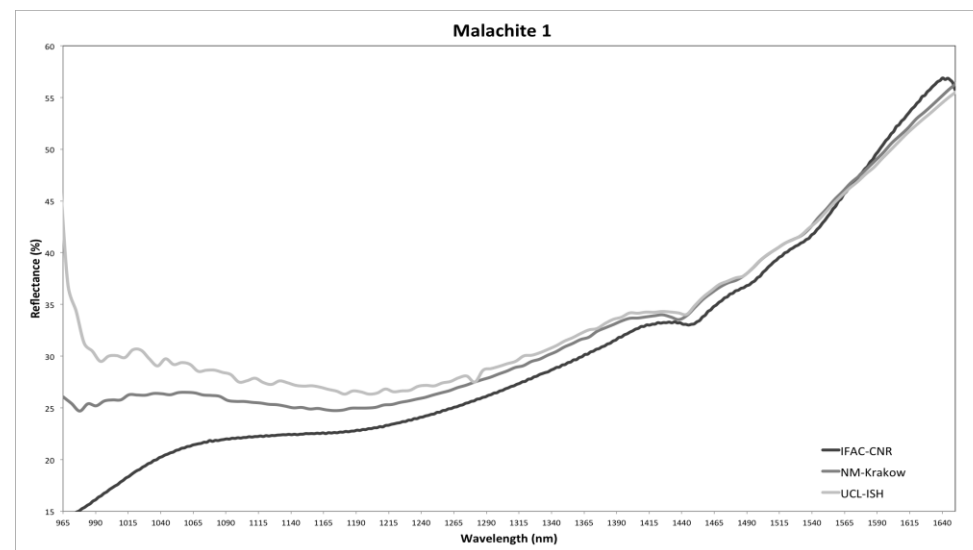
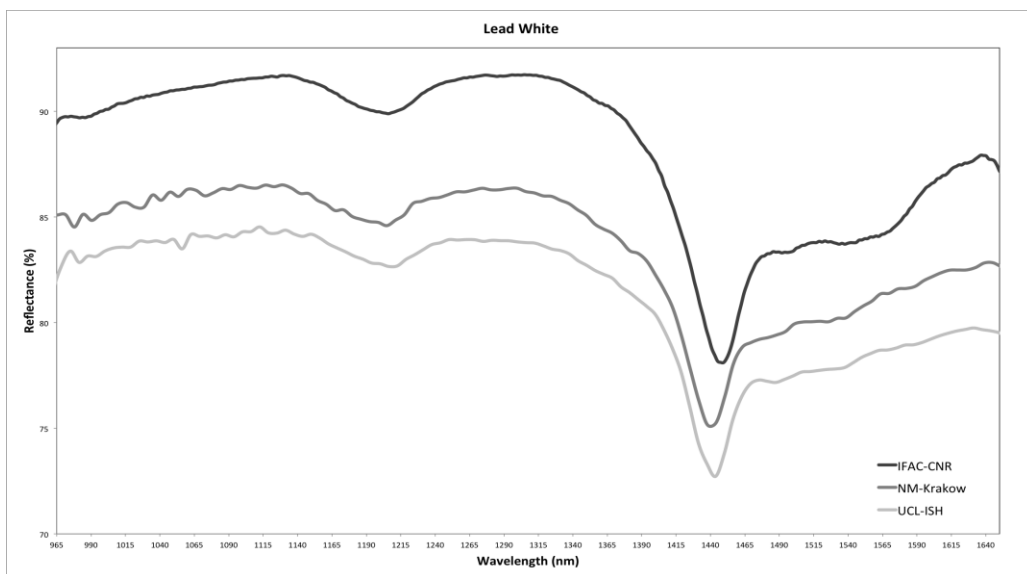
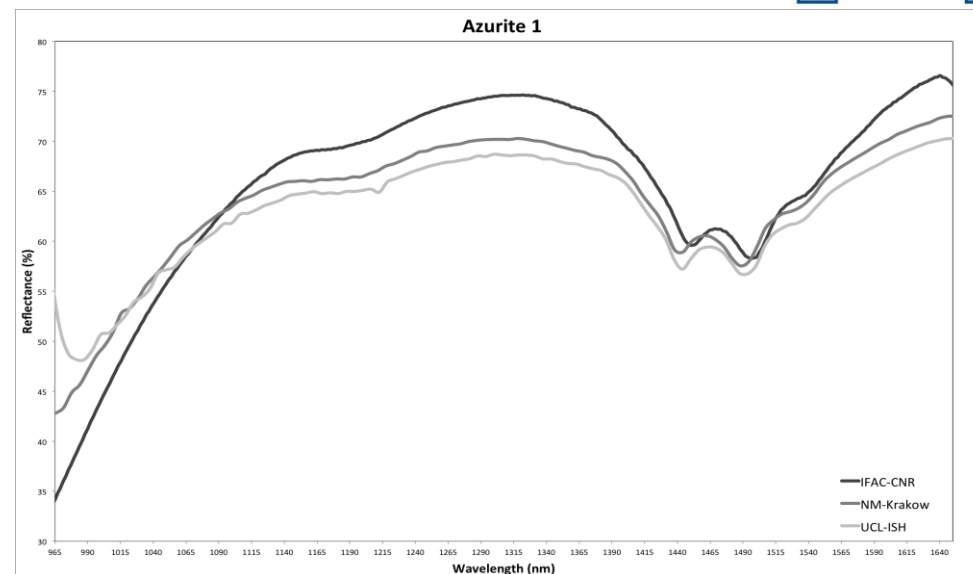
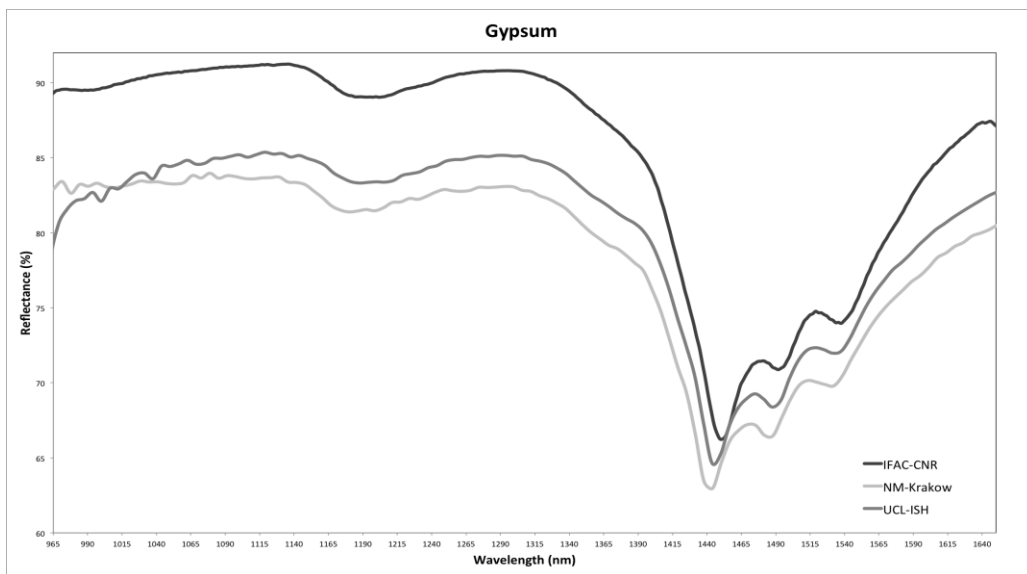
SphereOptics Zenith Polymer Wavelength Standard Detail 1450 – 1500 nm

COLOR & SPACE IN



Comparing Sampling Densities





Conclusions

- Spectral and spatial resolution needs of system determined by object and use of resulting data
- Accuracy and reliability of the data improved by understanding the systems, elements of data acquisition, and the affects of the instruments and methodology
- Value of scientific investigations increased by standardising and defining best practices
 - Reproducibility and comparability
- Collaborative endeavor and an interdisciplinary team required for imaging spectroscopy of paintings

Acknowledgements

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 - University of Brighton
 - University College London (UCL)
 - Analytik Ltd.
- National Museum of Krakow
- UCL Institute for Sustainable Heritage