



BEYOND VISION: PHYSICS MEETS AI



# Pigments and Brush Strokes: Investigating Painting Techniques Using MA-XRF and Laser Profilometry

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## OUTLINE

- Introduction
- Summary of the PROJECT “Mu.S.A” (Multichannel Scanner for Artworks)
- PROJECT “PERSEPOLY” (Protecting Heritage by X-ray spectroscopy and Profilometry): perspectives and research line, open issues



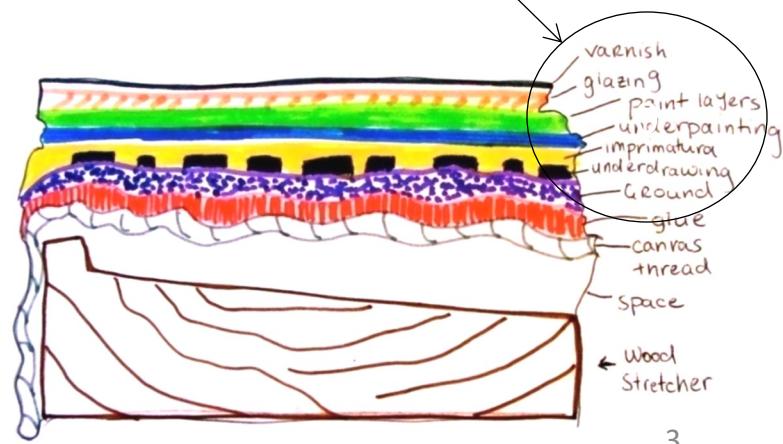
## INTRODUCTION

MANY LAYERS       MANY MATERIALS  
↓  
MUCH INFORMATION

As a consequence, **chemical composition** of the materials is investigated by XRF, FTIR, RS and other techniques for:

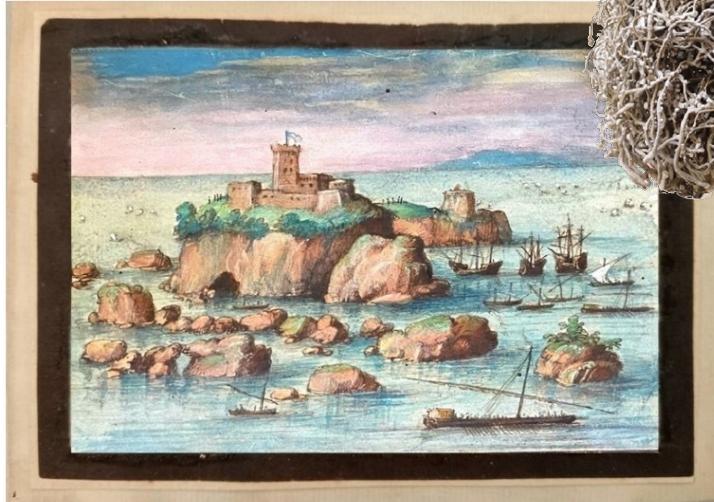
- deterioration evaluation and monitoring
- counterfeited art detection and characterization
- colour palette and reference materials reconstruction

Ritratto di Giovanna Tornabuoni, Ghirlandaio (1488, Thyssen-Bornemisza Museum, Madrid)





## INTRODUCTION



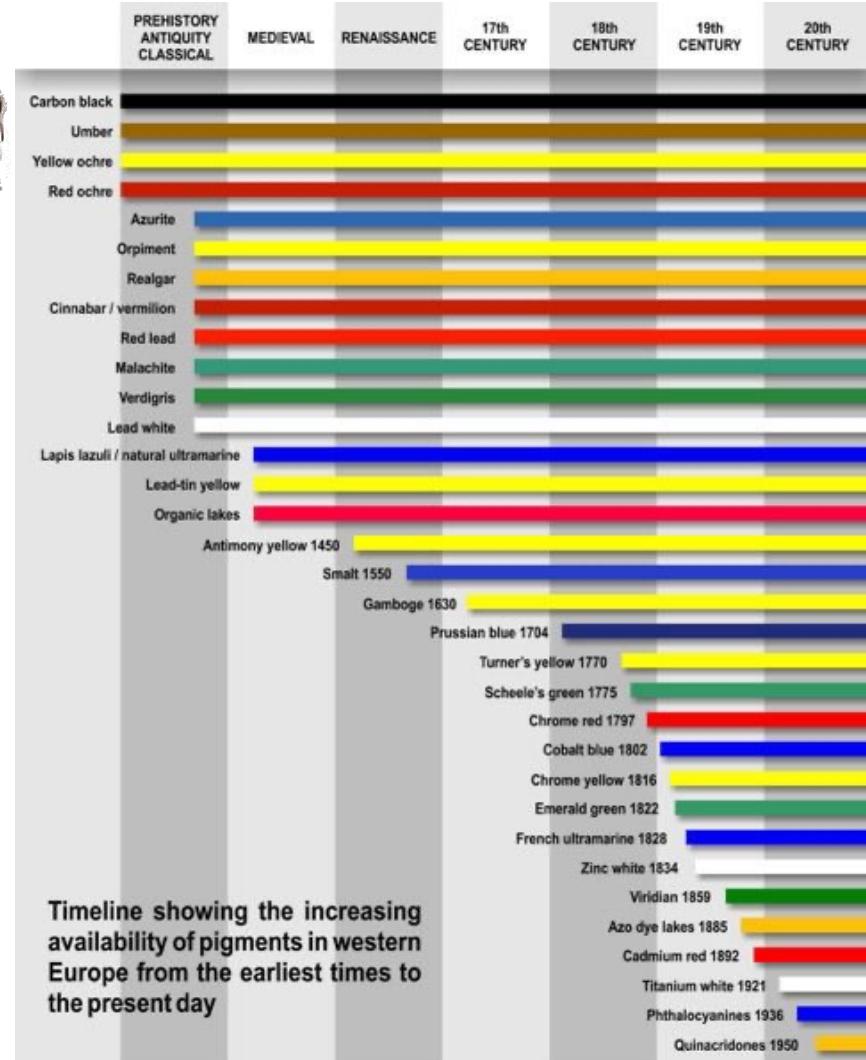
*Roccella tinctoria*

Gherardo Cibo,  
ca. 1575,  
110 × 160 mm

Diving into colours: a multi-analytical approach to a 16th century drawing by Gherardo Cibo", Vibrational Spectroscopy, 2023, 127, 103561

### Colour palette and chemical composition:

- more challenging after the end of the 18<sup>th</sup> century  
but before the introduction of the synthetic paints in the 20<sup>th</sup> century
- low significance in case of earlier artworks,  
in case of use of natural dyes  
or the choice of an essential and easy palette of coloured  
materials such as in the case of drawing and fast views





## INTRODUCTION

MANY LAYERS       MANY MATERIALS

MUCH INFORMATION

The surface of a painting is the only part showing visible and accessible **traces of the artist's hand**

Brushstrokes are at the same time color, pattern and texture and can bring plenty of features.

These features can:

- identify the artist's production and differentiate it from others
- be informative of the artist's thought
- be the only tool to describe contemporary art, also against counterfeited artworks

## PAINTING / ARTWORK

How the artist thought  
the image/space/light

How the artist decided  
to realize it practically

building sequence  
of layers and materials

How the artist  
used hands

deleting  
technical adaptation



## INTRODUCTION

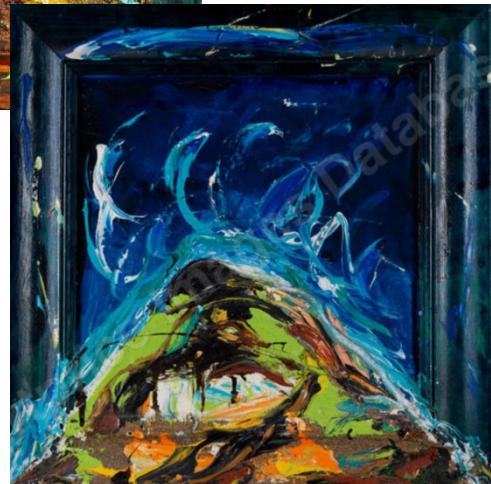
IDENTITY OF MATERIALS



PROCEDURAL AND TECHNICAL STUDIES NEEDED



Homogeneity  
in colour choice  
and paint  
composition



Beyond Vision: Physics meets AI 2023, Udine (Italy), September 1, 2023

Different composition,  
Space concept



I gigli d'acqua,  
Mario Schifano



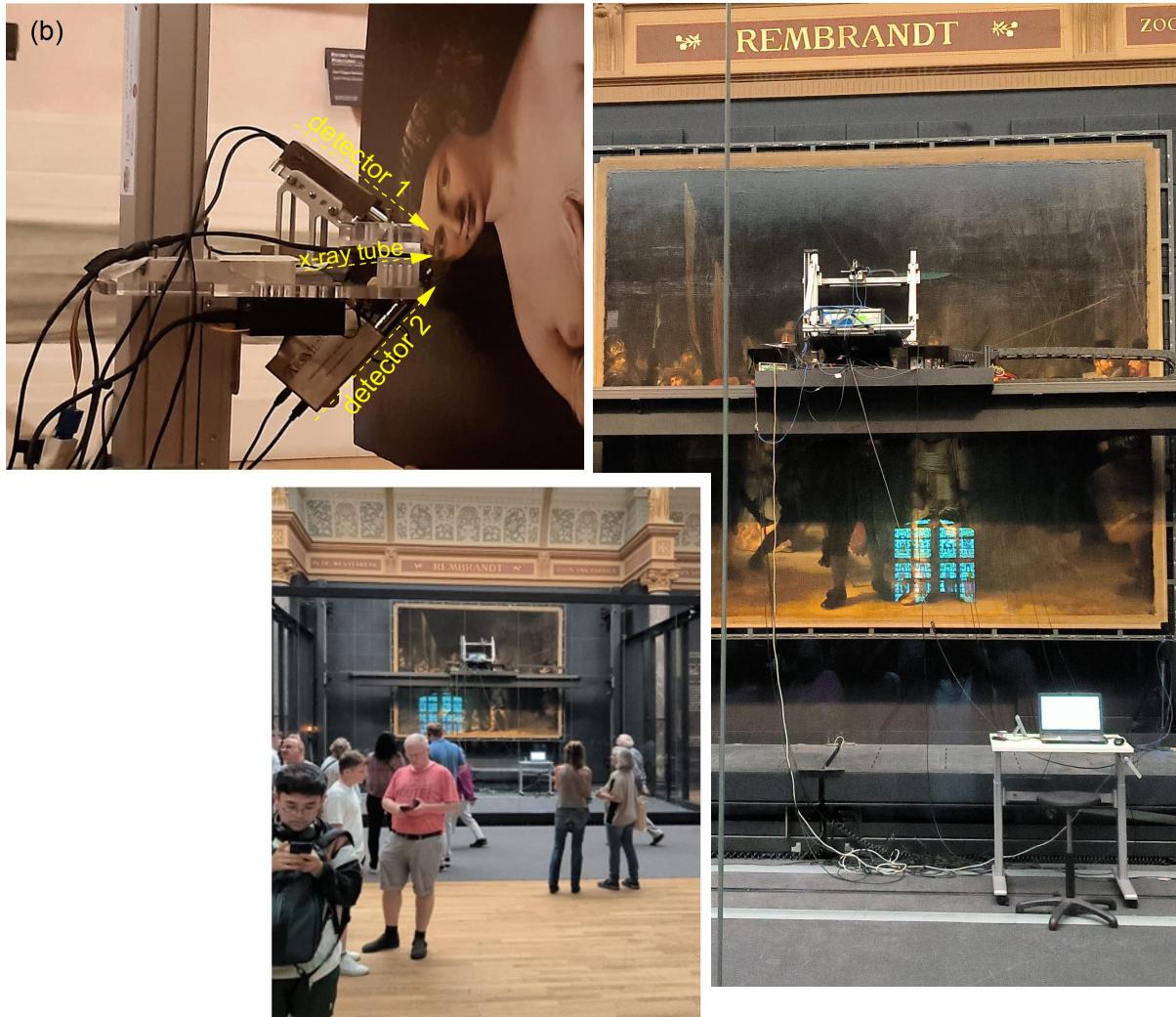
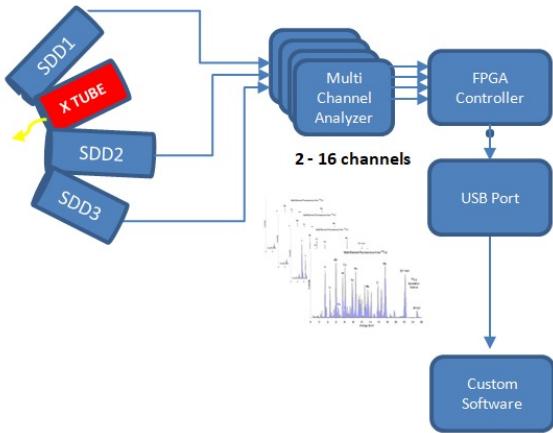


## PROJECT Mu.S.A. (Multichannel Scanner for Artworks)

### MUSA TARGETS:

- MA-XRF movable head
- plug –and –play approach
- **3 detector working simultaneously**
- portability

increasing S/N  
decreasing time  
autoassorb. evalutation





## PROJECT Mu.S.A. (Multichannel Scanner for Artworks)

### MAIN CASE STUDY:

2020 — 5th centenary from Raphael's death

Fornarina, Raphael, ca.1520



La Fornarina ed  
il progetto  
MUSA

MUSA progetto finanziato dalla Regione Lazio  
Ai progetto hanno partecipato: CNR, INFN  
e l'Istituto di Astrofisica e Planetologia Spaziali dell'Università di Roma Tre, Dipartimento SBaI di  
Sapienza Università di Roma, Av. Mississipi.



## PROJECT Mu.S.A. (Multichannel Scanner for Artworks)

PROJECT RESULTS: comparing elements, comparing lines

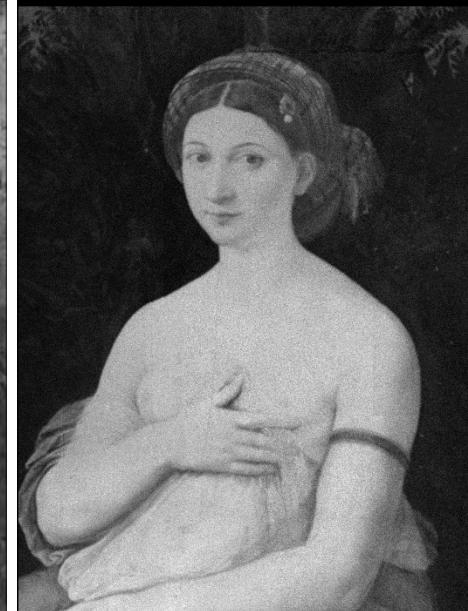
Cu & Fe – K line



Pb – L line



Pb – M line



## PROJECT Mu.S.A. (Multichannel Scanner for Artworks)

### PROJECT RESULTS: into Raphael's mind and view

By these two approaches some important details of the Artist's work could arise:

- personal involvement: pentimenti in the face/head which is the most refined part but also clearly hand drawn
- cultural frame: monochromaticity of the underdrawing (Alberti); coloured shadows (da Vinci); coloured imprimatura (XVI century innovation)
- creative process: reharmonization of the shadows to mantain the volume effect as a consequence of the changed background scenario
- creative process: personal choice of a “private” and deep space instead of the classical background scenario, scarcely characterized



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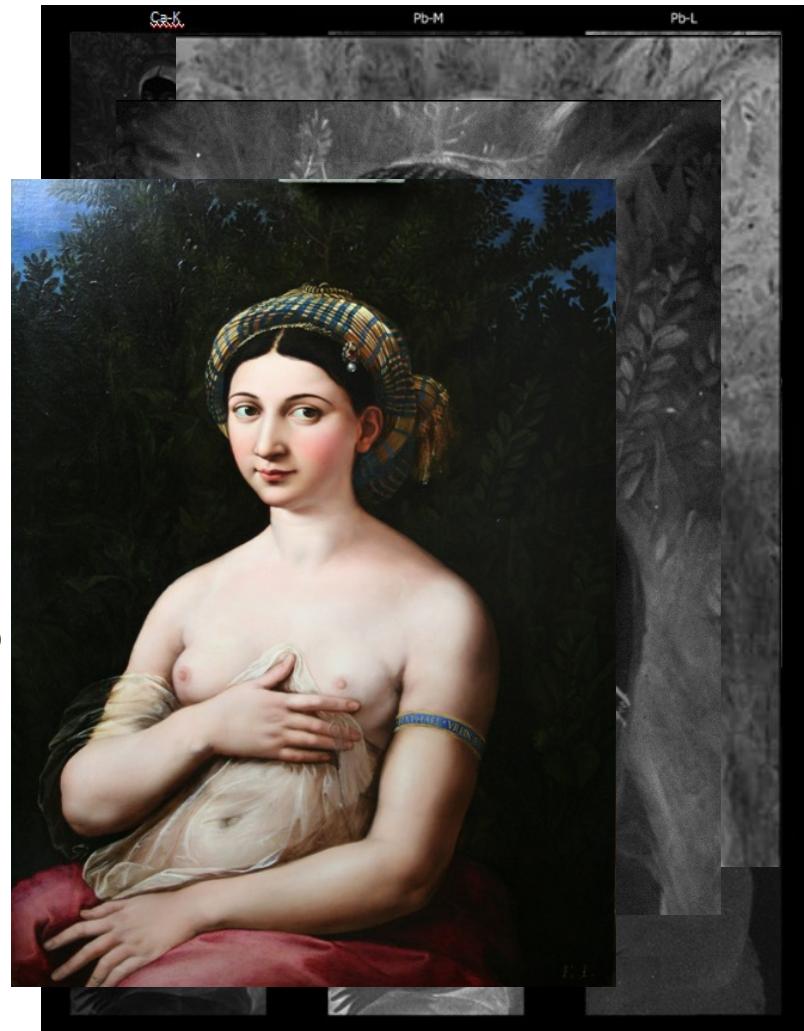


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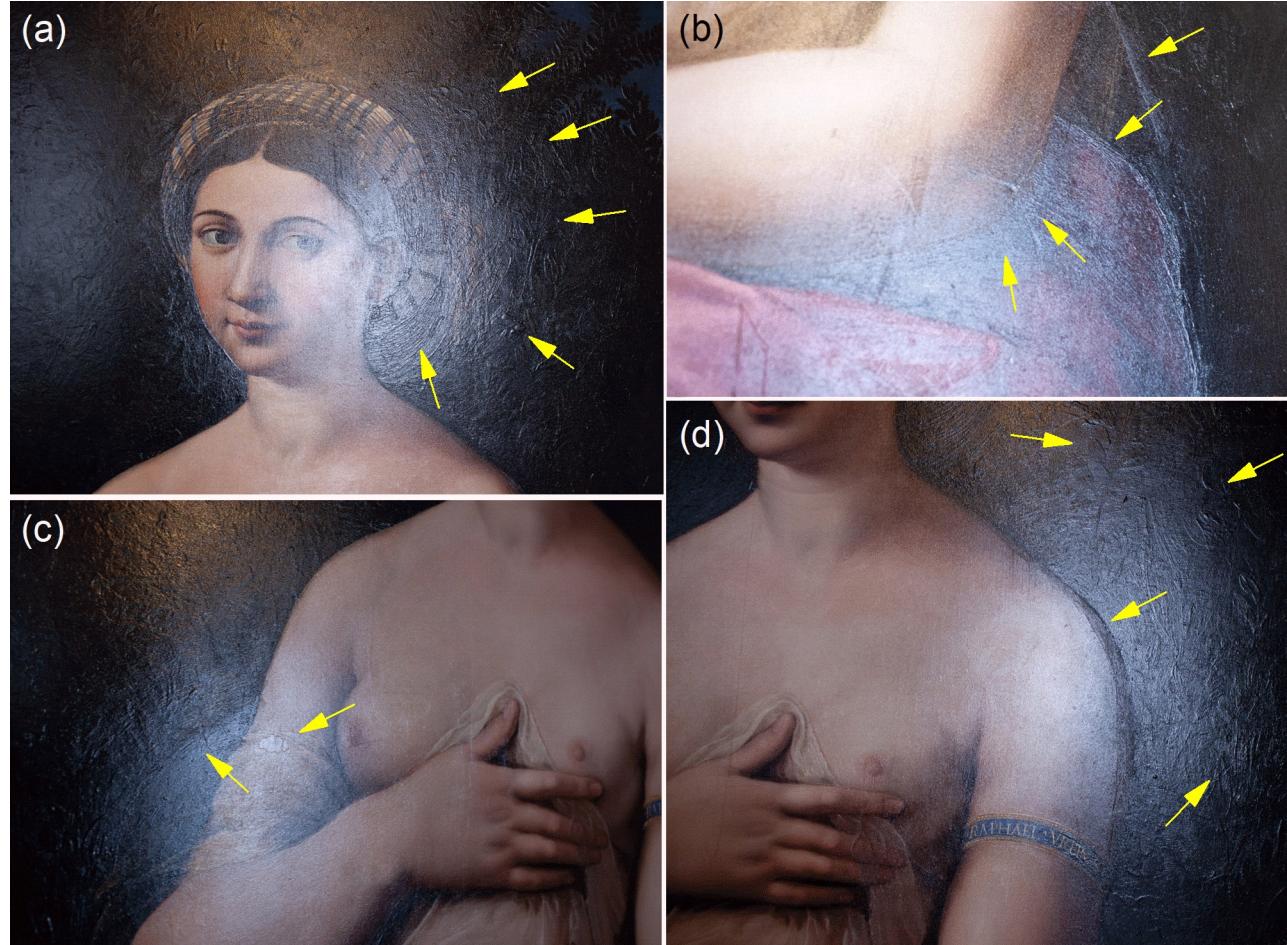


## PROJECT PERSEPOLY (Protecting Heritage by X-ray spectroscopy and Profilometry)

### OTHER OBSERVATIONS

The micro-topography can very informative on the followings:

- Changes on the left arm: what was the sequence of the layers?
- Turban: is the cretto actually continuous with the other coloured fields?
- Materic effect of the vegetal ground: was it scattering light to give the idea of movement?

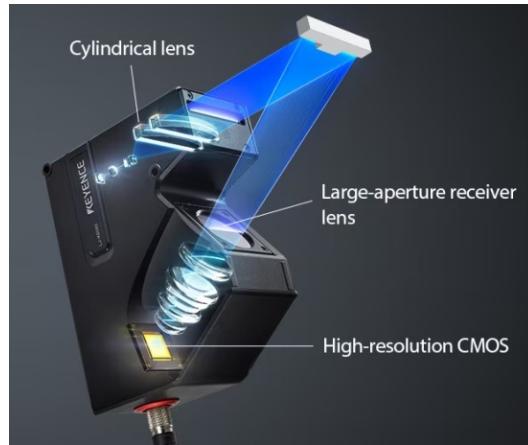




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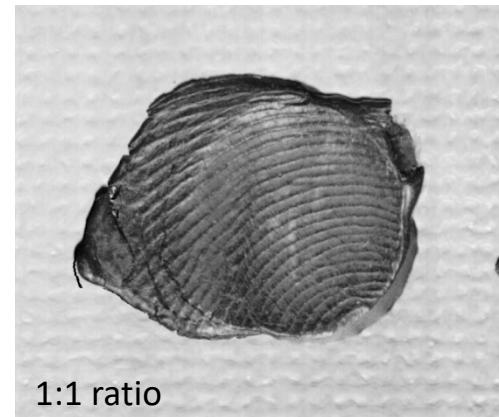
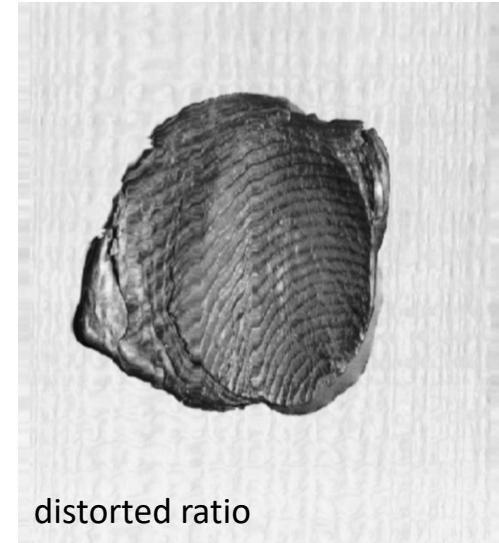
### PERSEPOLY TARGET:

enhancing the Mu.S.A. (scanner) by the implementation of an optical profilometer to survey the micro-topography of a painting surface



No-contact, non-destructivity, non-invasiveness, which make it suitable for implementation.

Commercial level instruments are equipped with arrays or matrixes of detectors with lateral resolution enough to detect the features of interest for painting surface surveying.



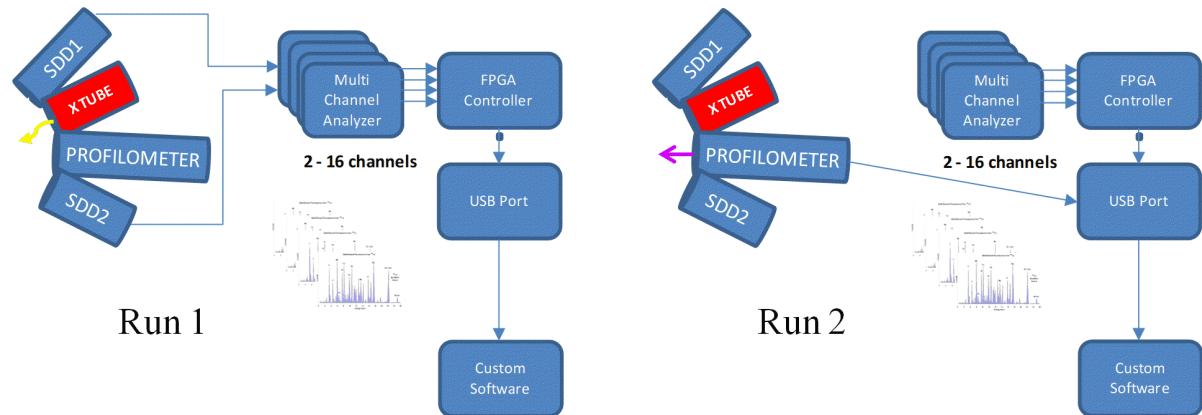
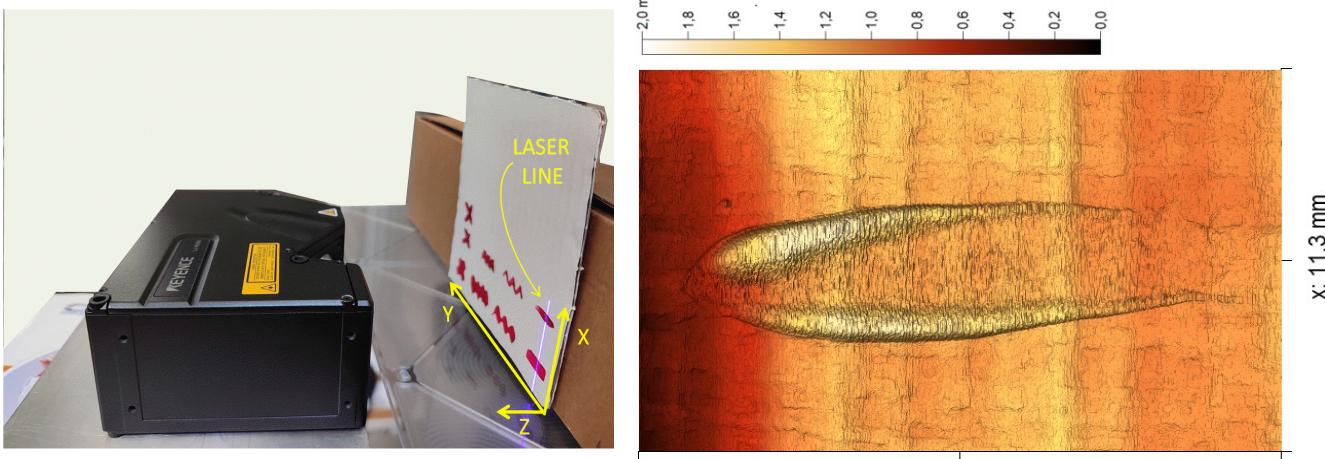


## PROJECT PERSEPOLY (Protecting Heritage by X-ray spectroscopy and Profilometry)

### PERSEPOLY TARGET:

To ensure optimal surveying,  
1:1 ratio between the lateral resolution along both x and y directions is to be reached by the right combination of sampling frequency and speed of the head.

The best results were obtained by 500 Hz freq. and a speed of 6.25 mm/s

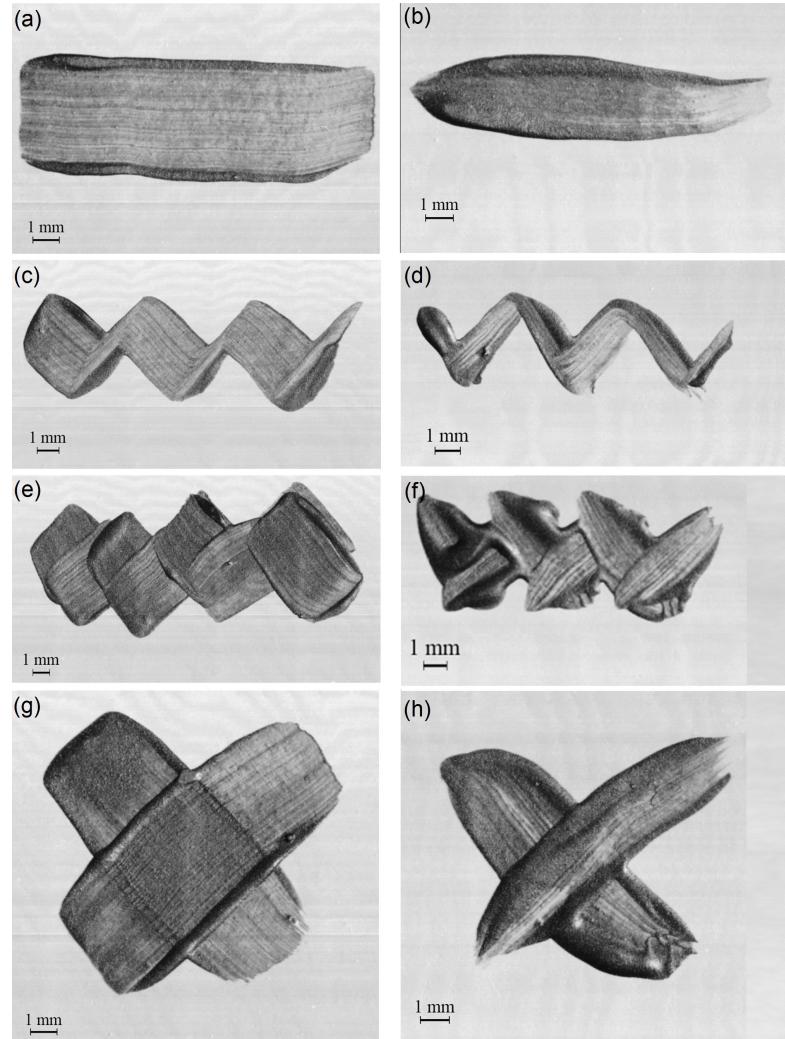




## PROJECT PERSEPOLY (Protecting Heritage by X-ray spectroscopy and Profilometry)

### UNDER INVESTIGATION:

- Variables considered: tip typology (squared, rounded), tip width, medium, load, dilution, crossing out, wet-in-wet/wet-in-dry stroke
- Features under investigation for uni- and multivariate analysis (MCA) : direction, longest dimension gradient, shortest dimension gradient, cross field roughness
- Is the direction of the brushstroke always recognizable?
- Is this true also when strokes are continuous and wavy or crossed or in absence of the end stroke?
- Can the raised edges of the brushstroke give reliable information on the stratigraphy?
- How does the roughness vary in the crossed areas of the painting in the different cases?

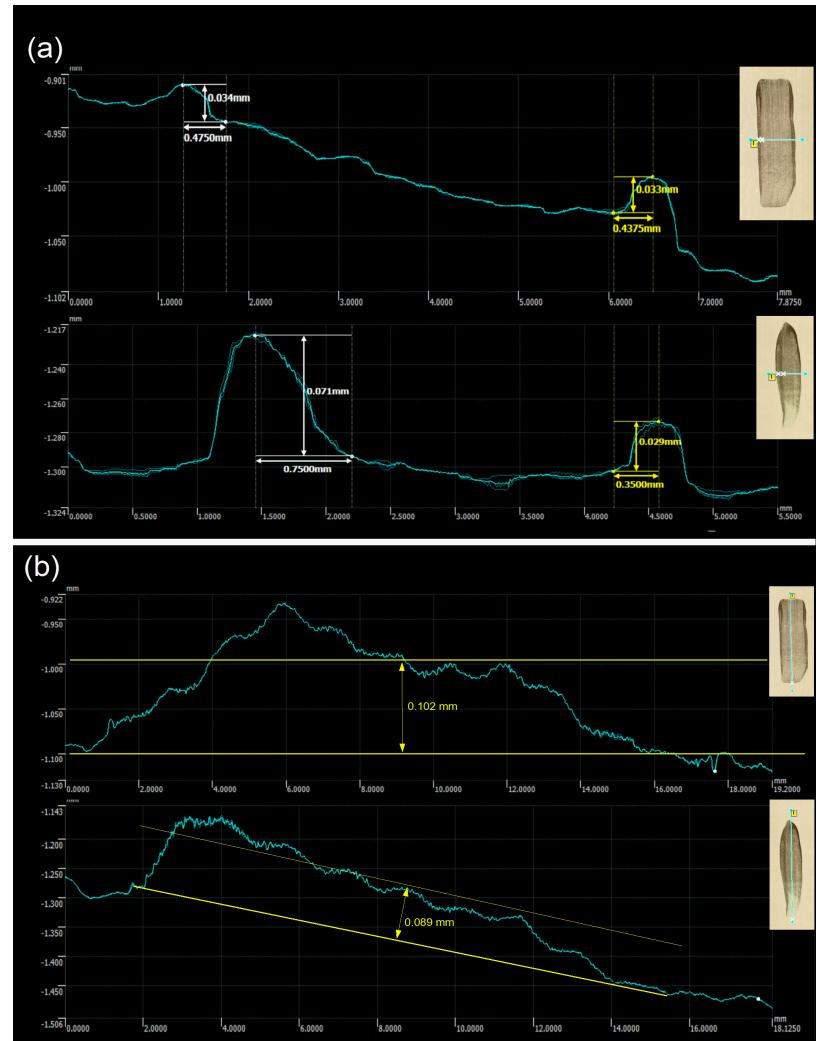




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## PROJECT PERSEPOLY: open issues

In view of future extended amount of data, AI applications are desirable especially in the field of counterfeited artworks detection but some critical points arise:

- the artworks of an artist available to train an AI could not be enough
- especially in the past times, artists could have worked in *studios* where it is hard or impossible to distinguish the various “hands”; moreover, the contribution of many artists frequently remained in the shadow of the Master's name
- an artist never maintains the same artistic features constant throughout his life and his production: he explores different views and this is reflected by changes in art practice and technique.
- a protective layer of varnish with considerable thickness usually covers the painting masking the true microtopography of the surface





## AKNOWLEDGEMENTS

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- Associazione Centro di Eccellenza Distretto Tecnologico della Cultura della Regione Lazio
- Regione Lazio  
Project MUSA, 2018-2020, n. B86C17000280002  
Project PERSEPOLY, 2021-2023, BUR-2021-38-0

ARS MENSURA

BARBERINI  
GALLERIE  
CORSINI  
NAZIONALI

Lazio  
INNOVA

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DISTRETTO TECNOLOGICO  
BENI E ATTIVITÀ CULTURALI  
CENTRO DI ECCELLENZA



REGIONE  
LAZIO

fesr  
FONDO EUROPEO DI  
Sviluppo Regionale  
2014-2020  
POR  
PROGRAMMA OPERATIVO  
REGIONE LAZIO

PROGETTO COFINANZIATO DALL'UNIONE EUROPEA



*Thank you for the attention*