

Direct analysis of paintings (Leonardo, Van Gogh, Courbet...) at the C2RMF Laboratory with portable instruments (XRF, XRD, FORS, ...)

Chemical analysis and study of appearance.

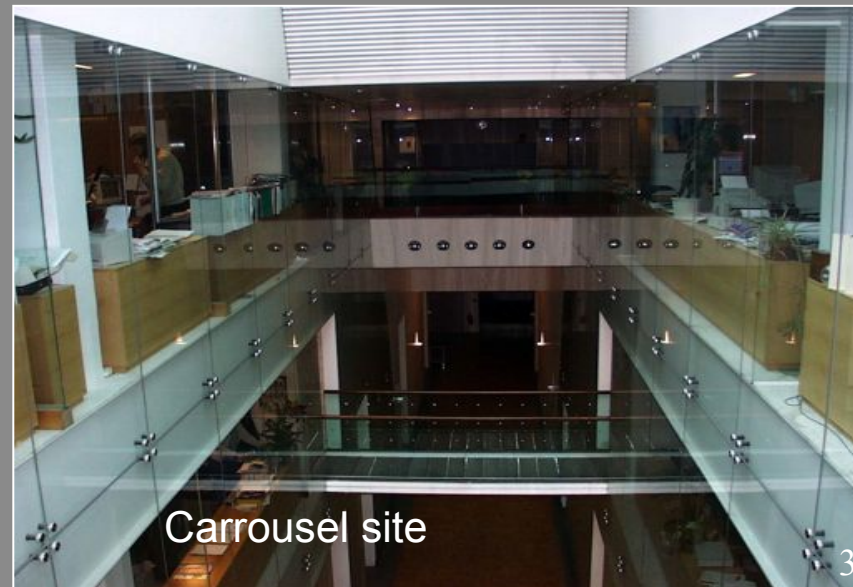
Michel Menu, C2RMF
michel.menu@culture.gouv.fr

Workshop on Portable X-ray Analytical Instruments for Cultural Heritage
ICTP, Trieste, 29 April 2013 – 3 May 2013

The Center for Research and Restoration of the Museums of France



Geographical situation



Missions of LRMF

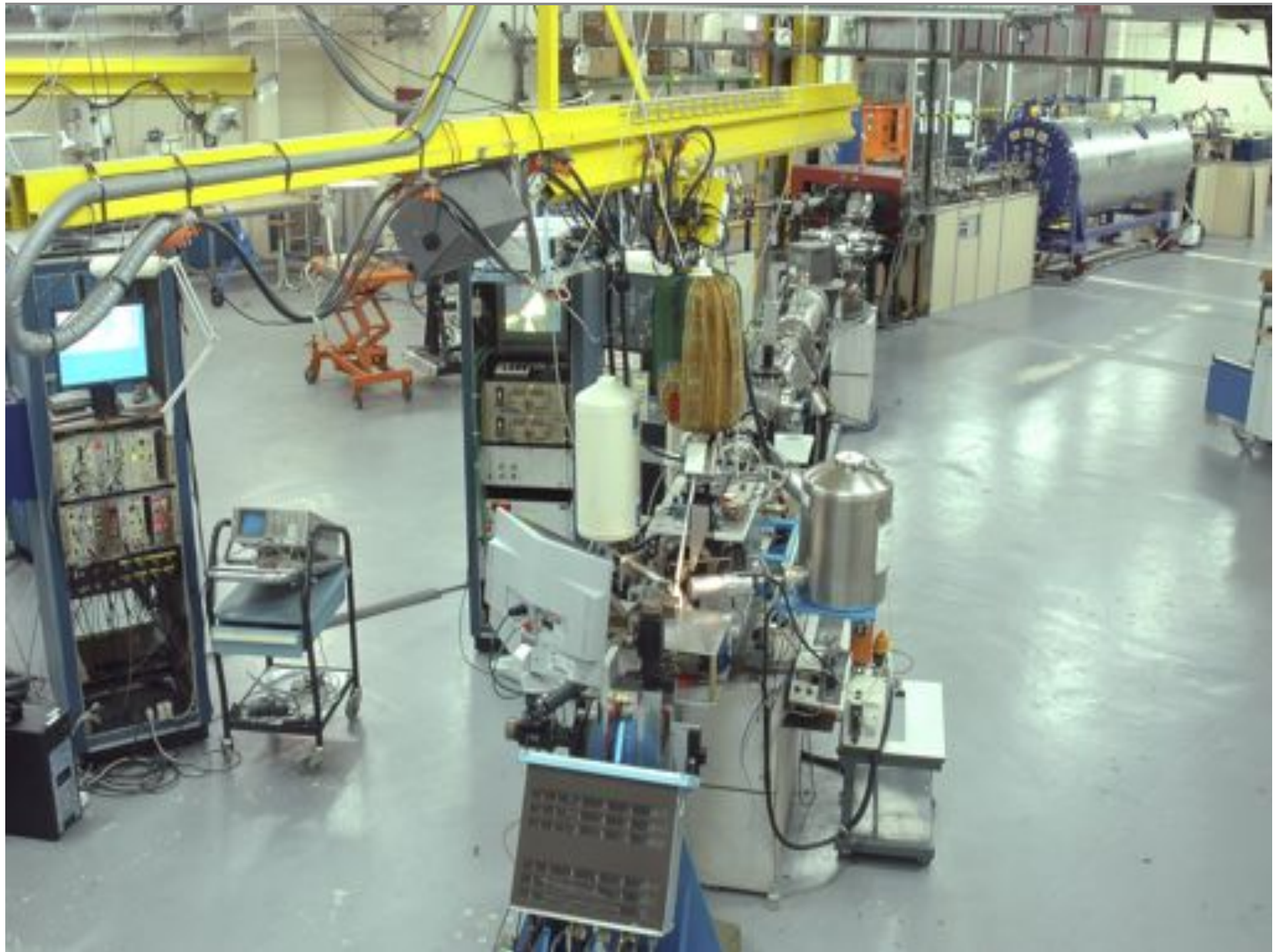
➤ Expertise works (short studies)

- acquisition (authentication)
- restoration
- exhibition

➤ Research works

- archaeometry: scientific studies of art and archaeological artefacts
- conservation science: studies of alteration mechanisms, restoration methods improvements...
- preventive conservation: control of museum environment

➤ Publication and teaching









Paris, Musée du Louvre











Expertise for museums

Authentication

Analysis before exhibitions









Jan de Beer, Born ca. 1475, Antwerpen, Died ca. 1528, Antwerpen
The Emperor Heraclius beheading the Persian king Chosroes II (Khusraw)
(ca. 1515-1520).

Oil on panel, 24x42,5cm









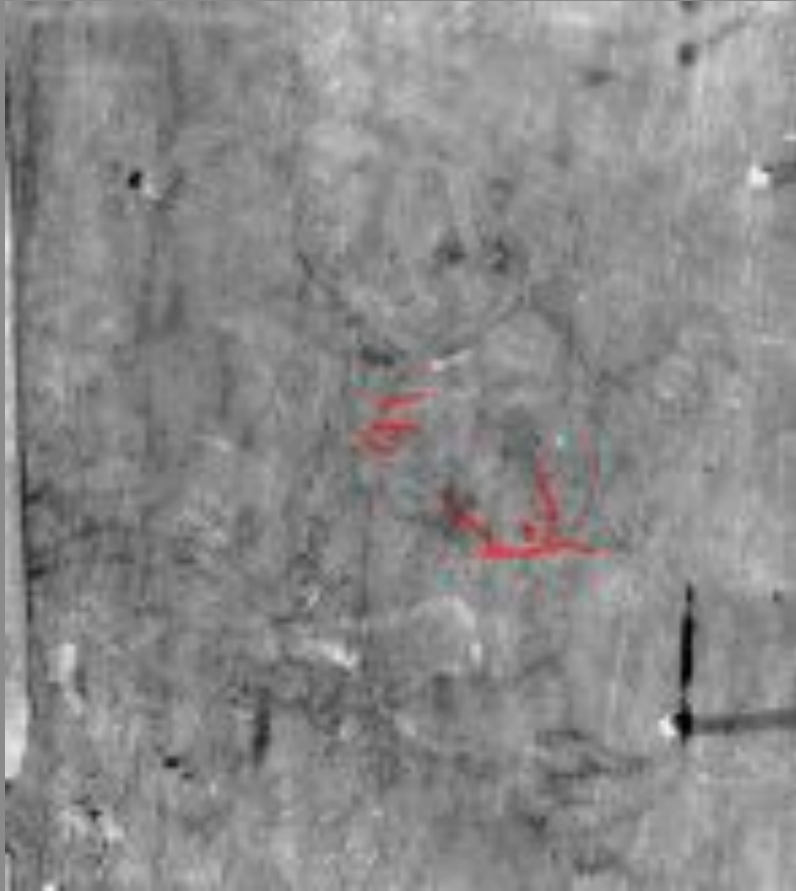






F 396. LEONARD DE VINCI "La Yngia, Santa Anna et 'Madame Jeanne'" - Paris, Musée de la Ville de Paris - 1977 - gravure - 10cm - Bibliothèque nationale de France - Département des Manuscrits - LAF 1061 - C2002 - F. Lambert - 15/09/08





MFX analysis









PbL
25000-35000



Hg L
0-1000

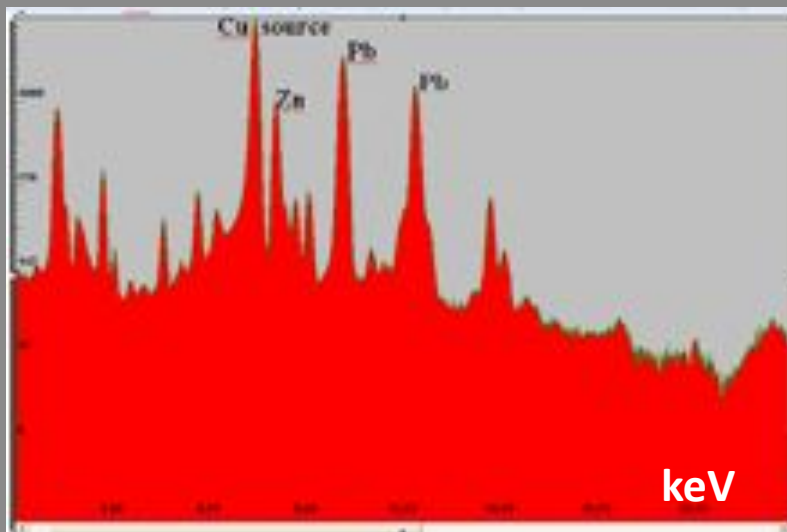




In situ analysis of object surfaces by portable X-ray diffraction and fluorescence

Introduction

- *In situ* analyze of works of art
- Portable equipment
- XRF for elemental analysis
- XRD for structural information



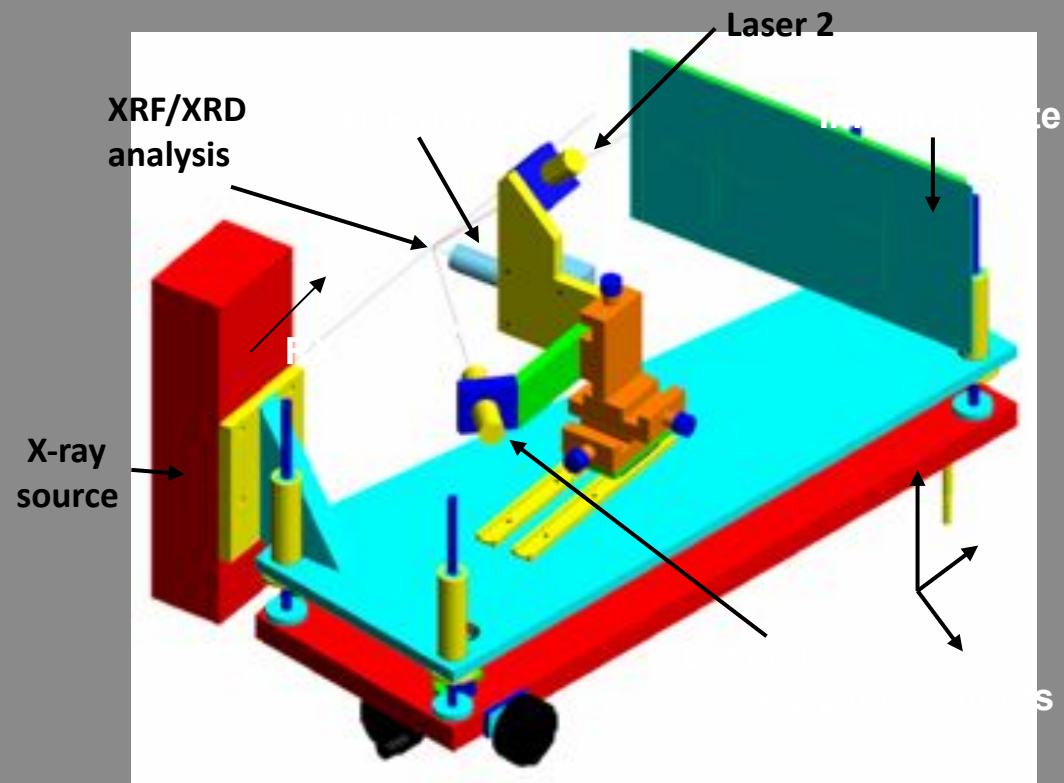
XRF spectrum of lead compound



XRD-XRF apparatus in front of a Van Gogh's painting at the C2RMF laboratory

XRF and XRD equipment

- X-ray, microfocus air cooled tube
- Cu anode X-ray source Cu $K\alpha$; $E=8.047$ keV; $\lambda=0.154$ nm
- 4 mm diameter parallel beam (slits)
- angle of the beam : 10° from the surface of the painting
- surface analyzed of about 4×3 mm²
- silicon drift detector for XRF 7 mm² Si; 12.5 μ m Be, best resolution 136 eV
- two dimension detector for XRD collection (imaging Plate)



XRF and XRD equipment



Andrea Mantegna - *Pala di San Zeno* (Verona)
Restoration in Opificio delle Pietre Dure
Firenze (Italy)

- From 25 cm to 250 cm above ground level

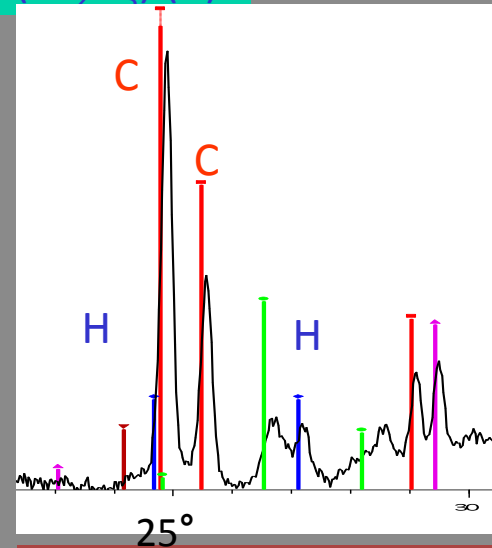
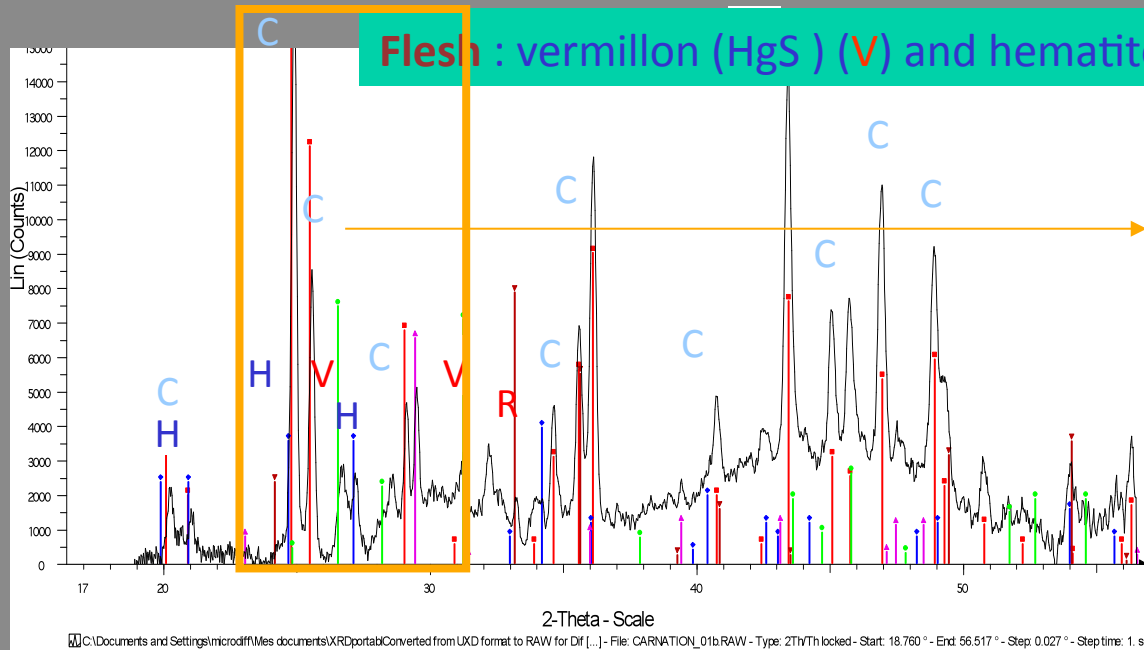
Leonardo da Vinci

Blue colors and flesh tones



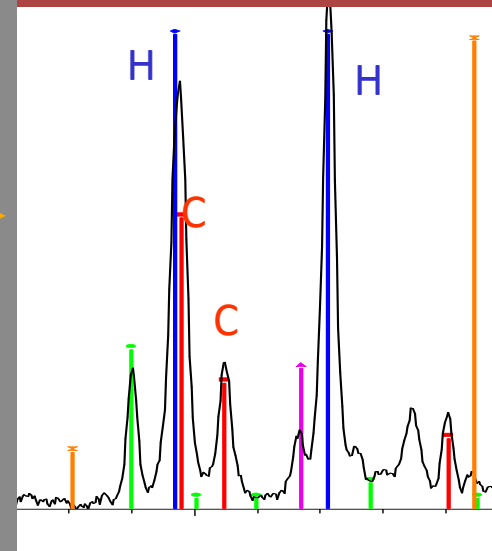
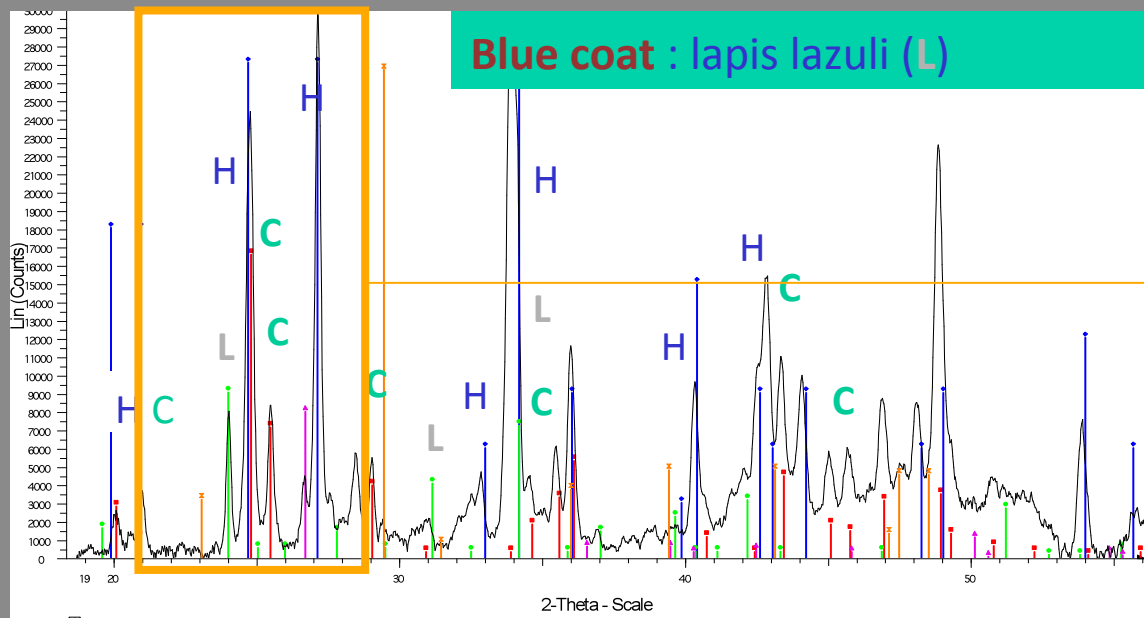
La Vierge, l'enfant Jésus et Sainte Anne, Louvre





Hydrocerussite (H)

Cerussite (C)



Van Gogh

Ground layer



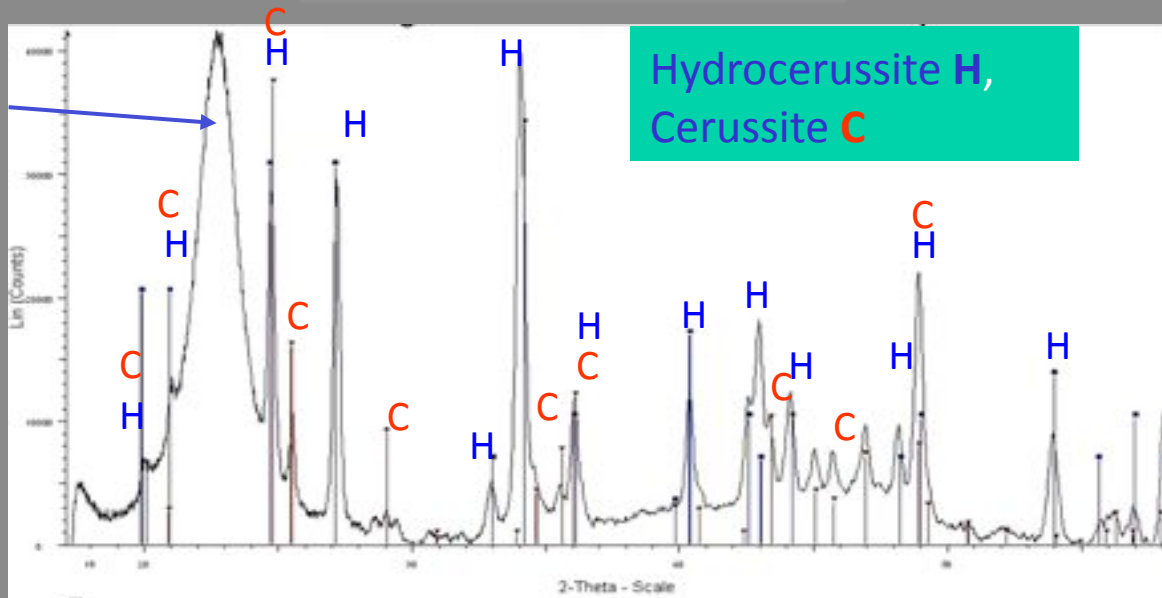
La chambre à Arles, Orsay, Paris



The bedroom, Van Gogh museum, Amsterdam

XRF : Pb

Cellulose of support



A comparative study of Vincent van Gogh's Bedroom series, Ella Hendriks and al., National Gallery Technical Bulletin, 30th Anniversary Conference September 2009,

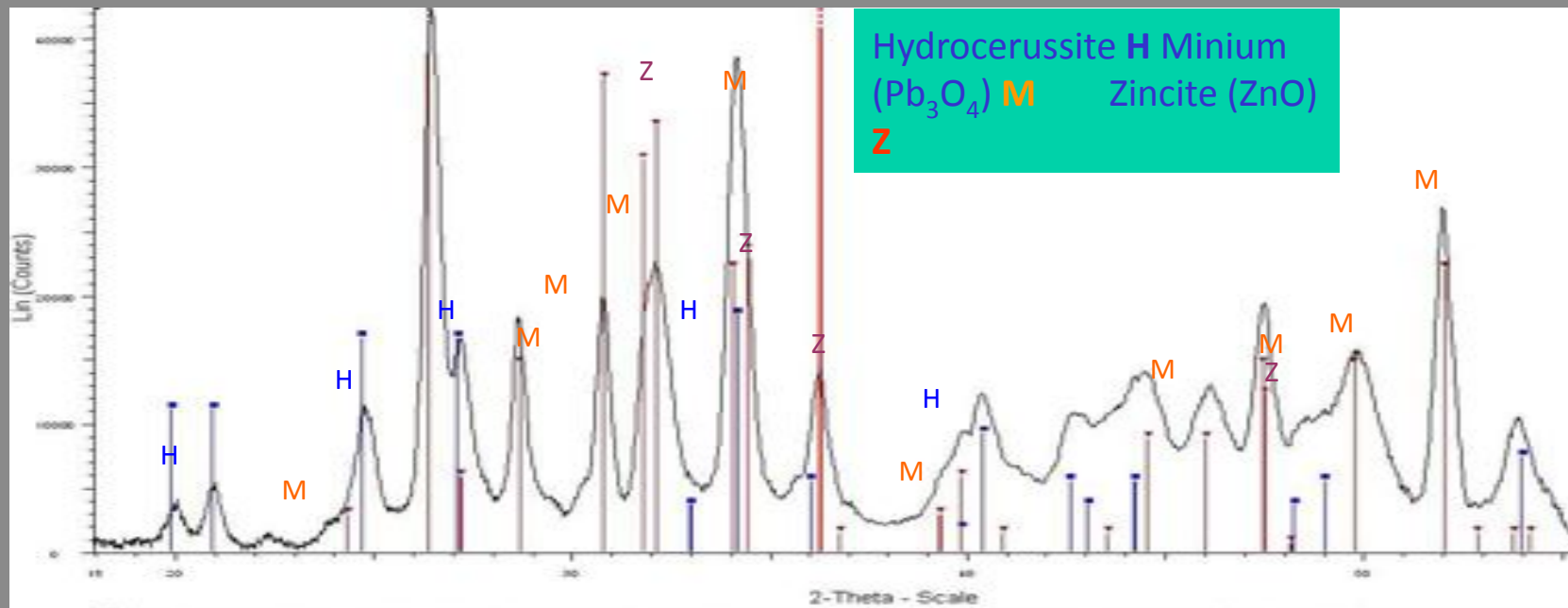
And Workshop Van Gogh Museum, Amsterdam 24-26 June 2013: "Van Gogh's studio practice": <http://bit.ly/145kLz4>

Van Gogh

Red layer



XRF : Zn Pb

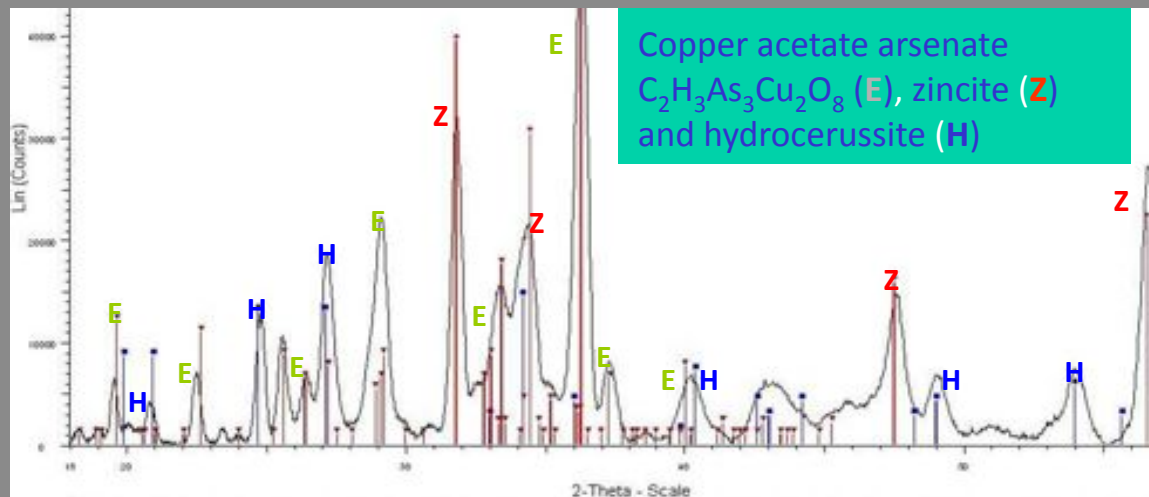


Van Gogh

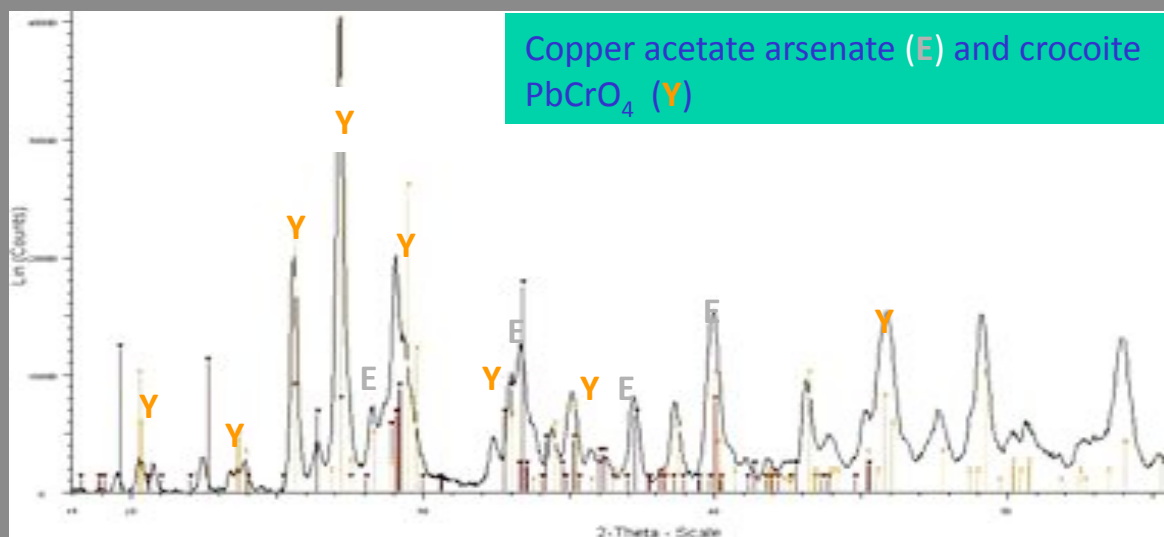
green colors



XRF : Cu As Zn Pb



XRF : Cu As Pb Cr



Conclusion



Painted skin of buffalo
Quai Branly Museum Paris



Rouffignac caves, France



CHARISMA project : Cultural Heritage Advanced Research Infrastructures:
Synergy for a Multidisciplinary Approach to Conservation/Restoration
<http://www.charismaproject.eu/>

Acknowledgments :

Jacques CASTAING (CNRS),

AGLAE team (C2RMF),

CHARISMA Project

In situ analysis of Prehistoric Cave Paintings by
portable instruments



In situ -XRF portable

X-ray fluorescence developed at C2RMF

Location: Deux Ouvertures, Ardèche, France in 2009 C2RMF with the collaboration of J. Money.



Commercial system : Niton XL3

Location: Villars, Dordogne, France in 2008 C2RMF with the collaboration of D. Genty and F. Tereygeol.



In situ -XRF portable (C2RMF)



In situ - XRF-DRX portable

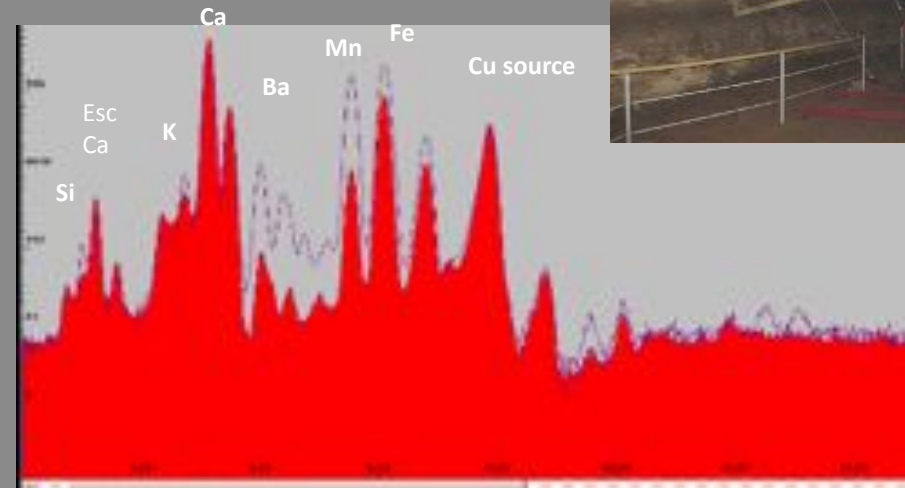
Location: Rouffignac, Dordogne, France in 2009
C2RMF with the collaboration of J. et F. Plassard and MNHN

Informations

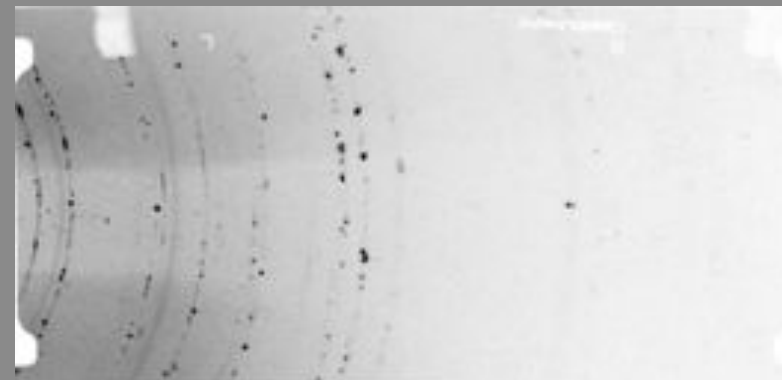
- chemical and mineralogical identification of the pigments



Fluo X



Diffraction



DRX (C2RMF) à Rouffignac



Portable Raman

Informations

- organic ?
- identification of pigments

Location: Rouffignac, Dordogne, France in 2009
C2RMF with the collaboration of J. et F.Plassard

Parois horizontales, Grand plafond



Parois courbes, Frise des dix



IR Reflectography

- Distinguishing pigments of different physical properties

Rouffignac, Dordogne



Villars, Dordogne



3D Photogrammetry

La Garenne Blanchard, Indre



La Garenne Blanchard, Indre

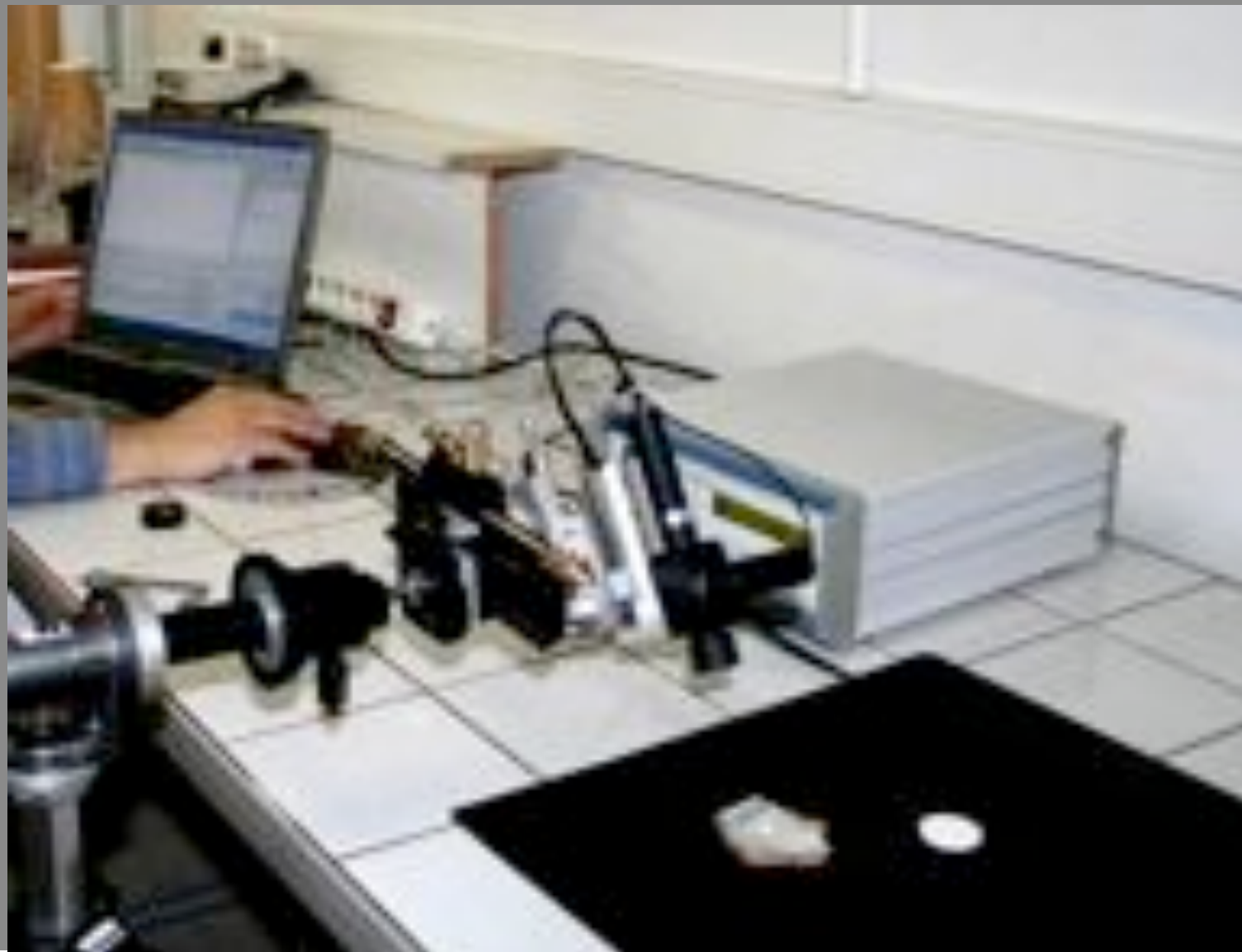


Déroulé des parois de la grotte, après apposition de la texture des photos sur le maillage de points issu de l'enregistrement avec le scanner



Measurement of the appearance: color, roughness

THE GONIO-SPECTROCOLOR METER





Spectrocolorimetric measurements

Protoptype realized by the C2RMF at the occasion of a European research project:

« *Research related to Standards, Measurements and Testing* »- 1994-1998.

Commercial version : *RUBY* by STIL company.

Back scattered light

Probe spot: 1-6 mm²

No contact, WD 75mm





Watteau's colorimetric study



Watteau's colorimetric study

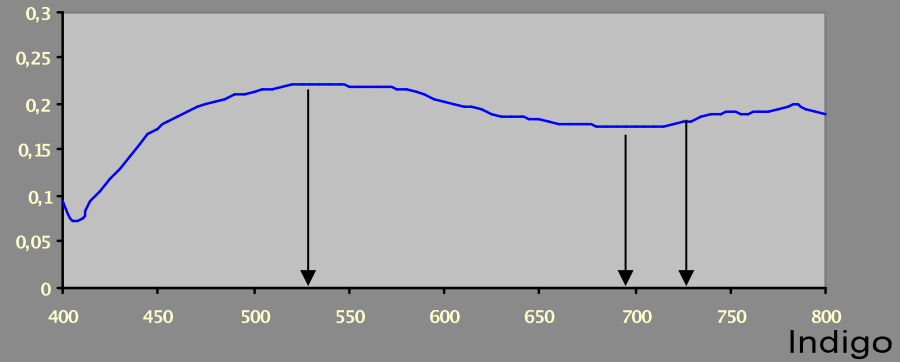


Watteau's colorimetric study

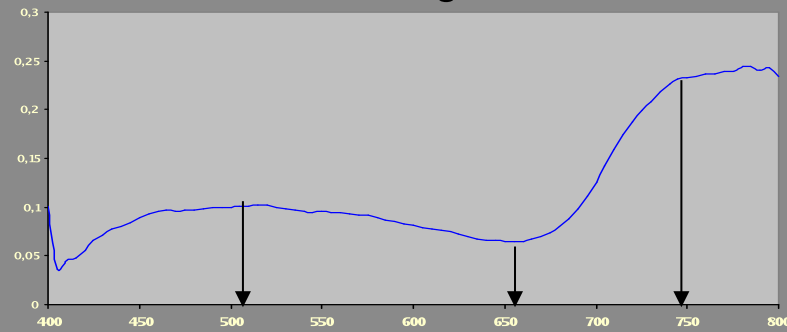


Watteau's colorimetric study

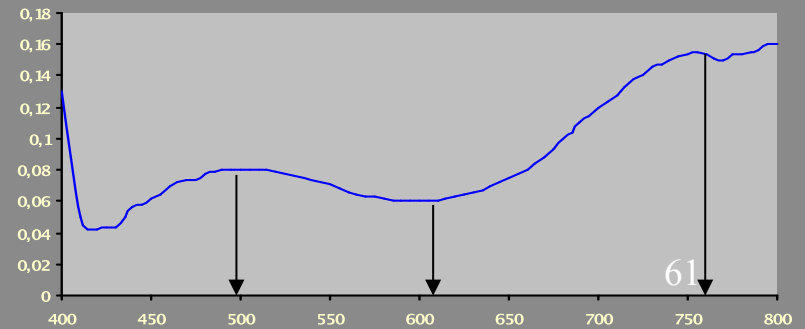
Prussian blue



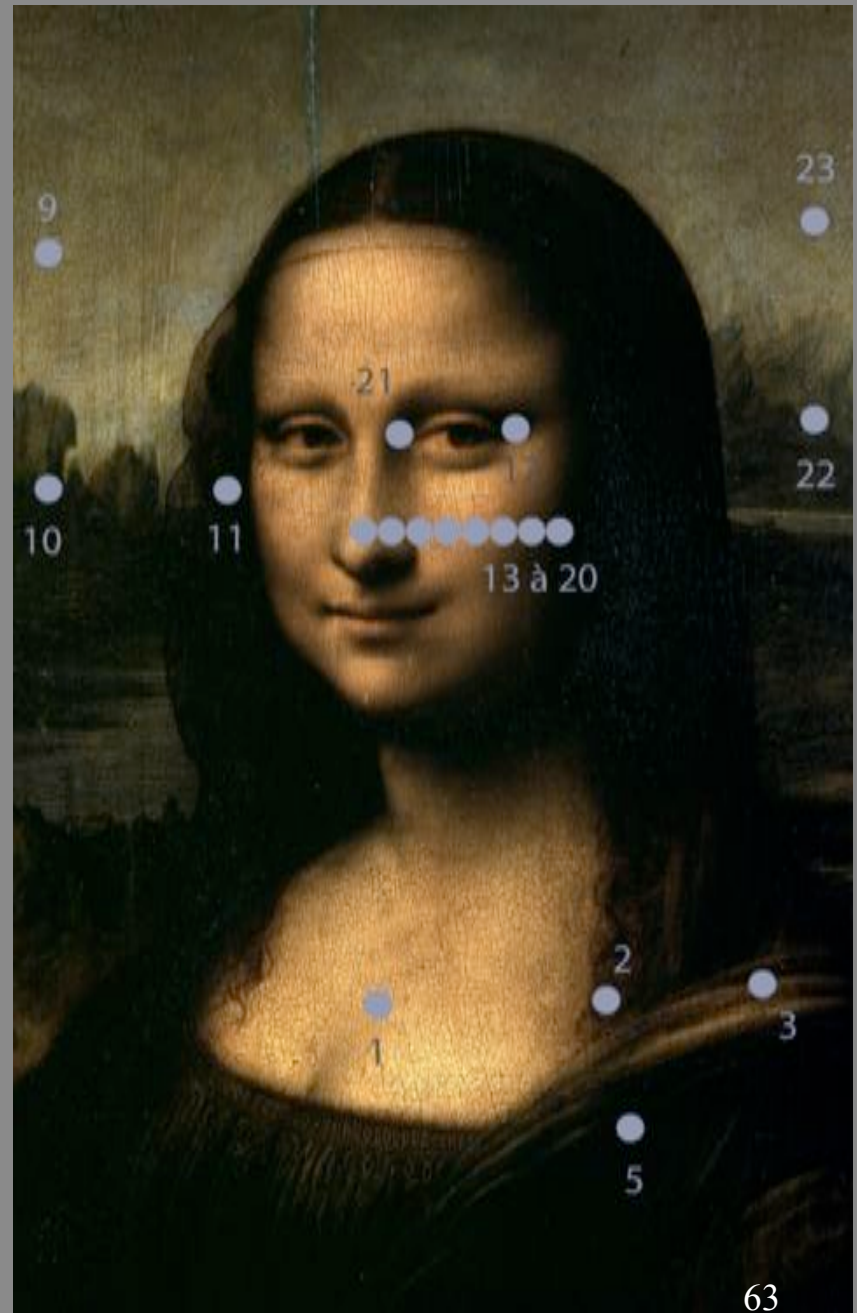
Indigo

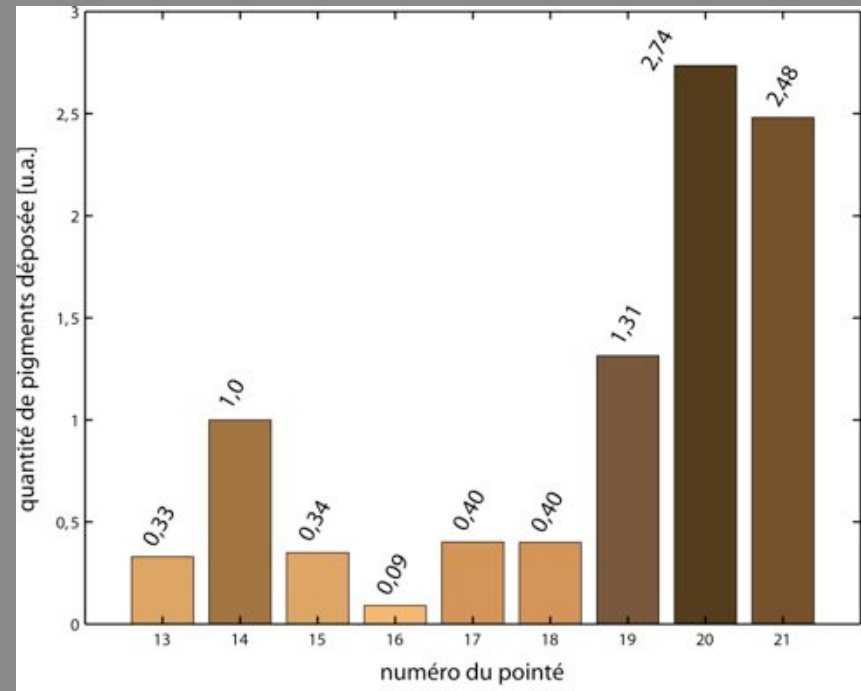
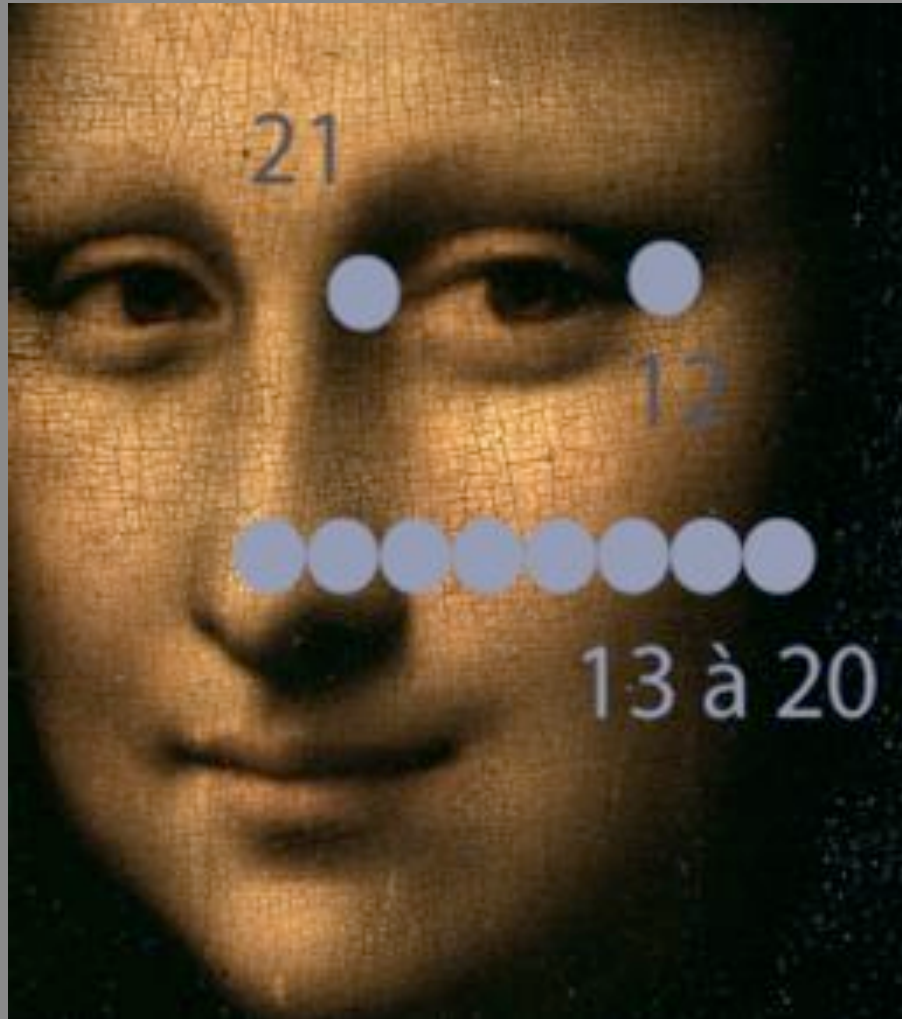


Lapis Lazuli

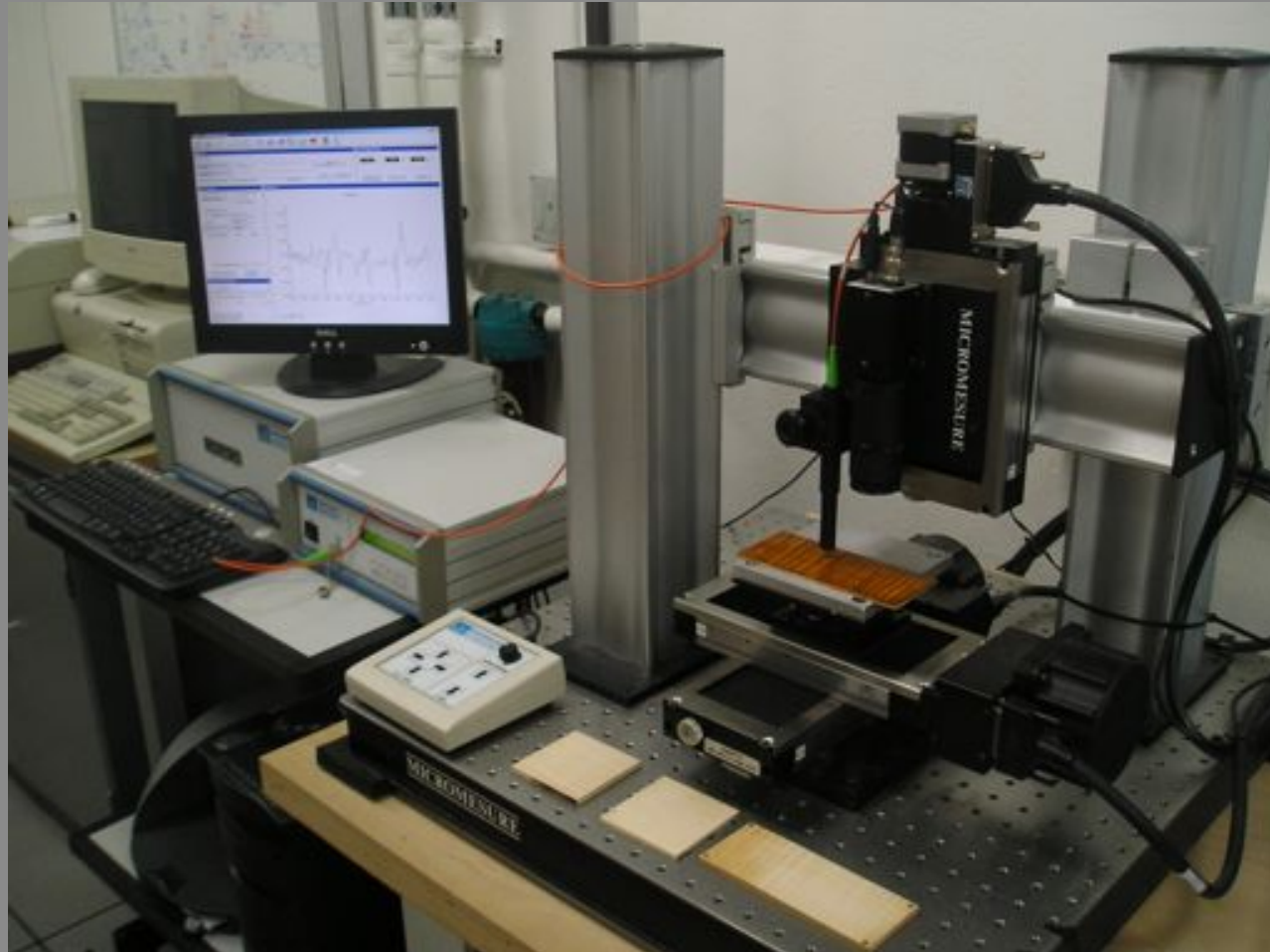








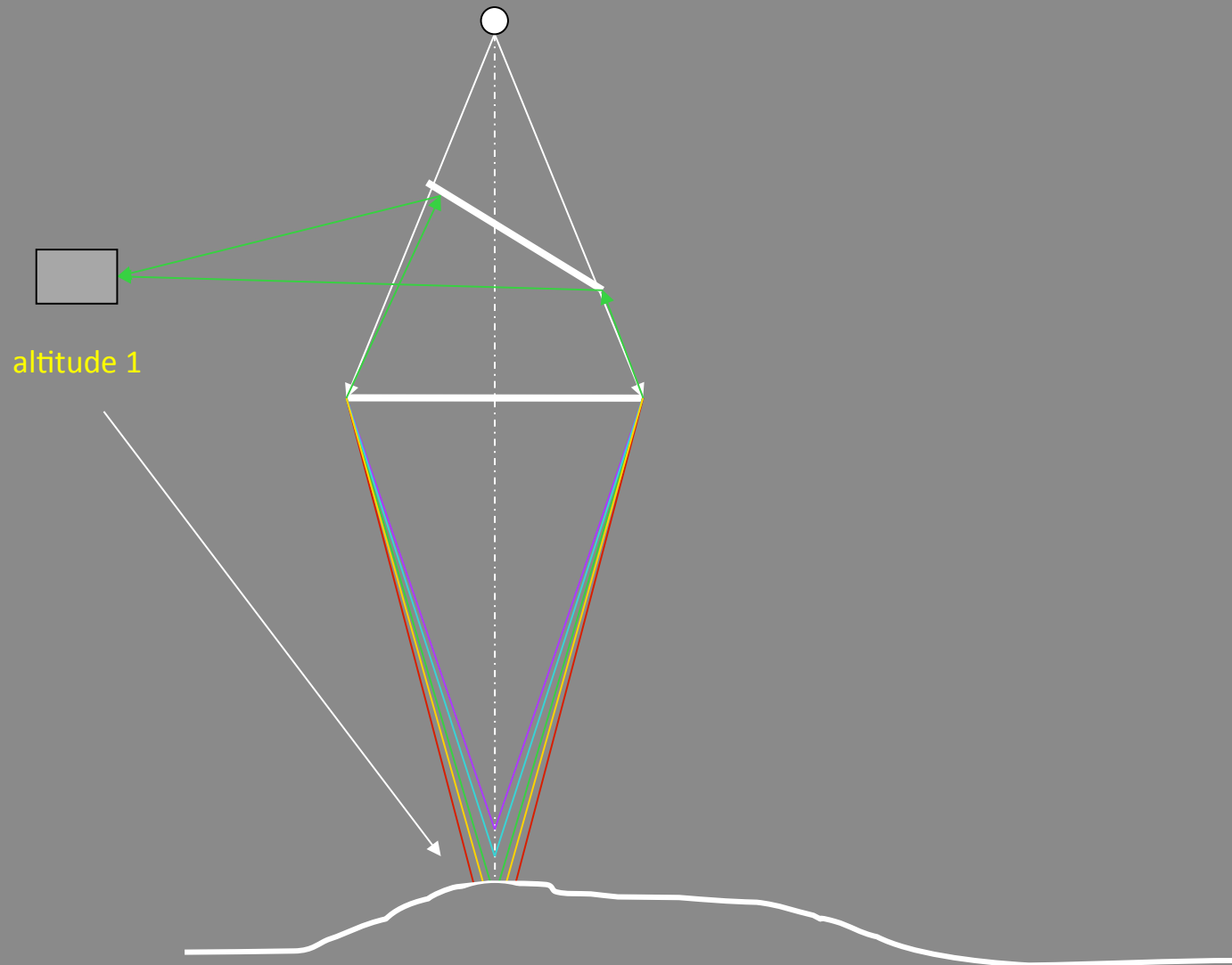
Measurement of surface roughness



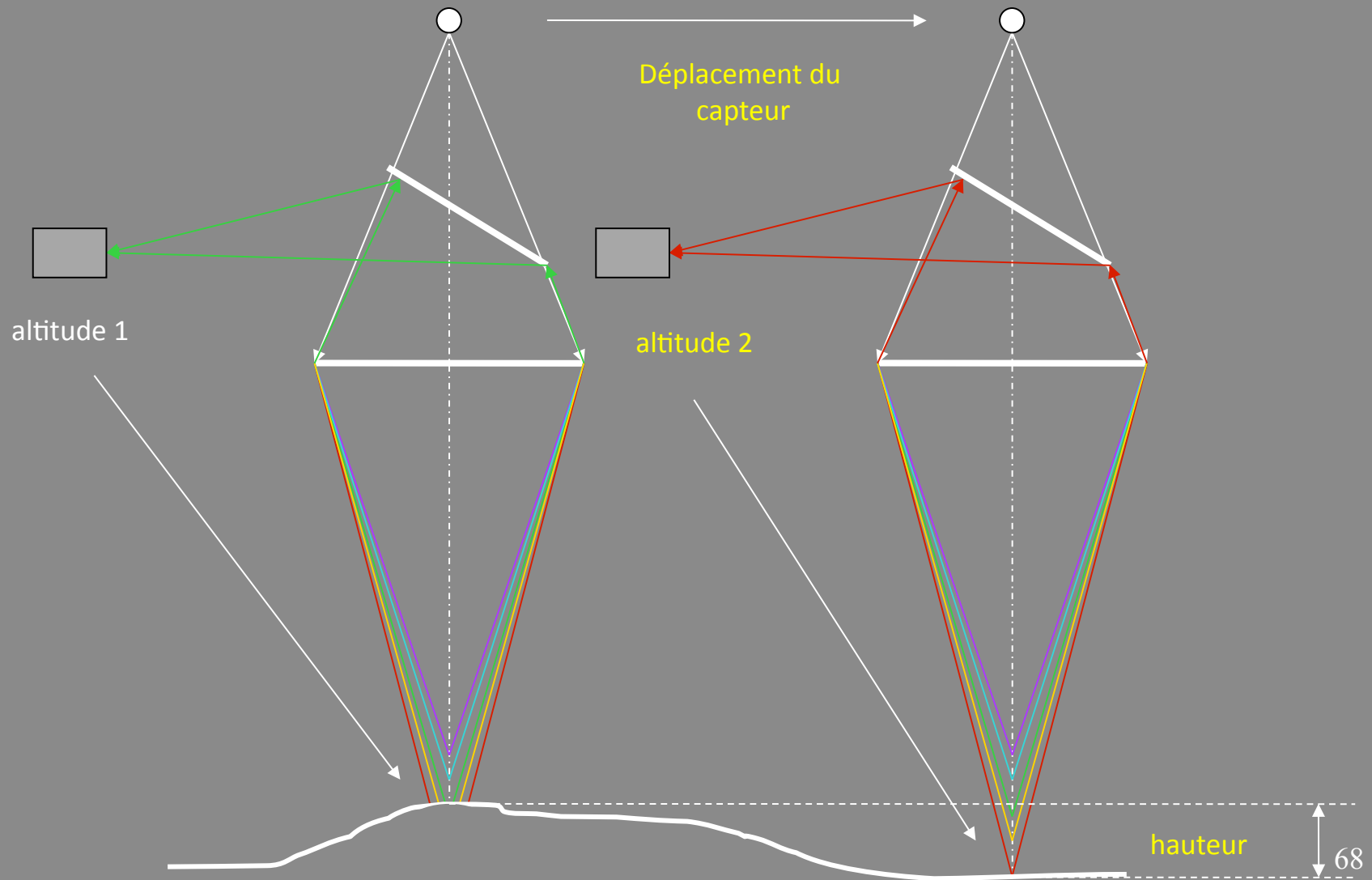
Measurement of surface altitude



Measurement of surface altitude



Measurement of surface altitude



The polish study of sculpture from Desiderio da Settignano, artist of XV^o century

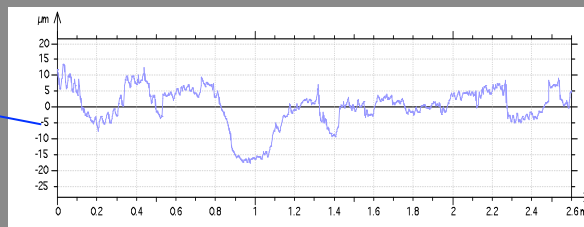
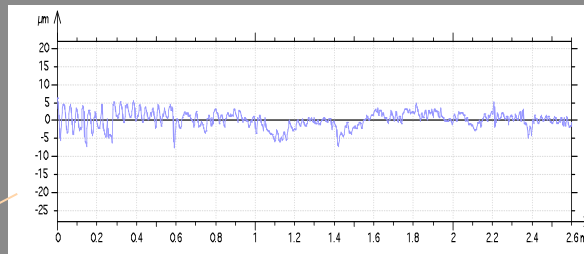
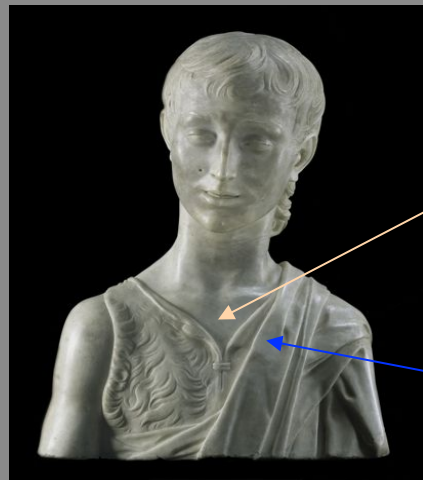


The polish study of sculpture from Desiderio da Settignano, artist of XV° century

The measurements performed permit to notice a small difference of polish between different parts of the sculpture. For instance, the mean roughness of a naked part is $Ra = 1,23\mu\text{m}$ and that of the cloth $Ra = 2,43\mu\text{m}$, while it is three times larger in the hair zone.

However it is not clear if such a difference is the signature of the artist's technique or is due to weathering.

Results



*Saint JohnBaptiste measurement
(Louvre)*

In the museum gallery

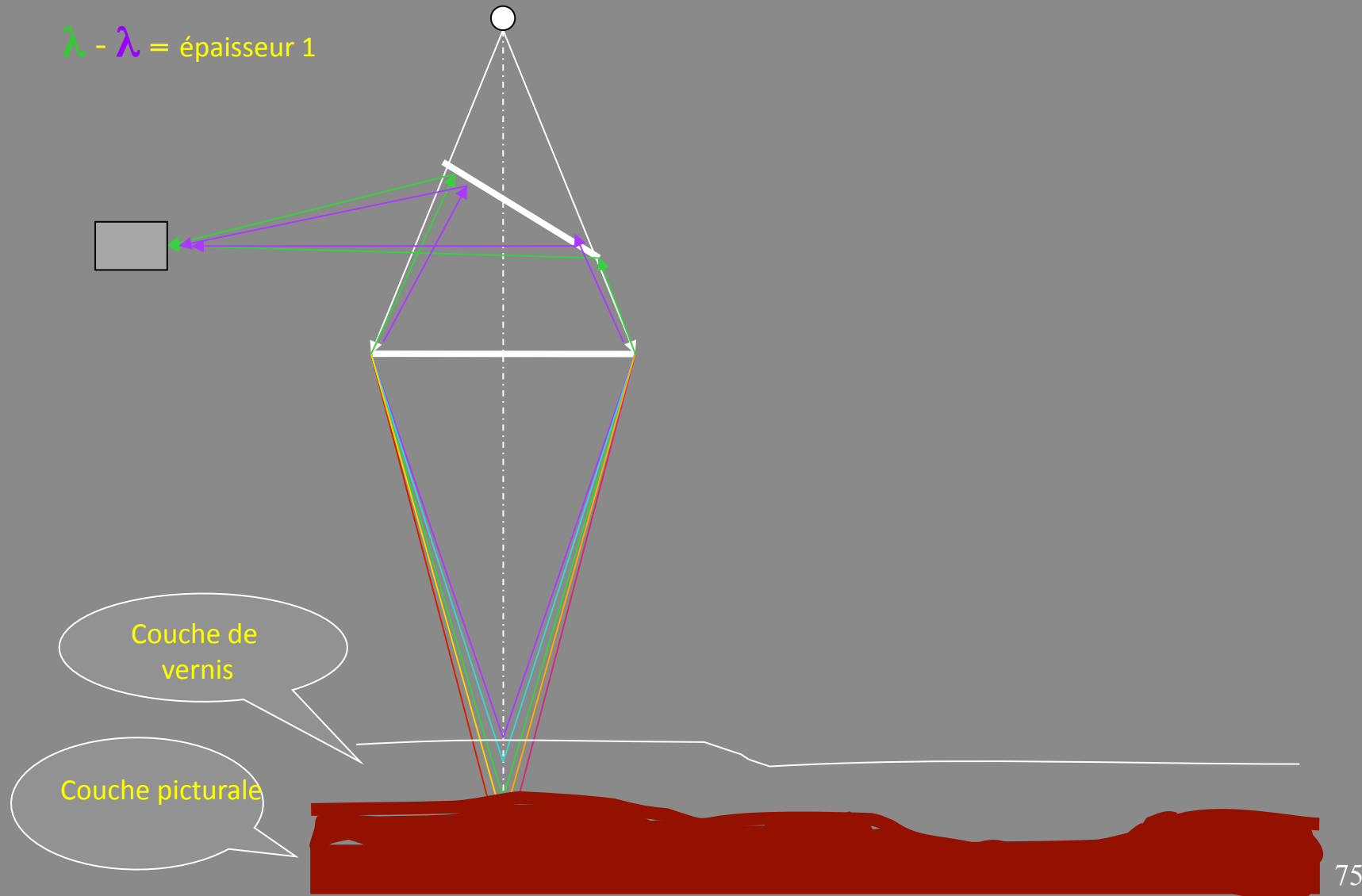




Thickness measurements

Measurement of thickness of transparent layers (glaze, varnish...)

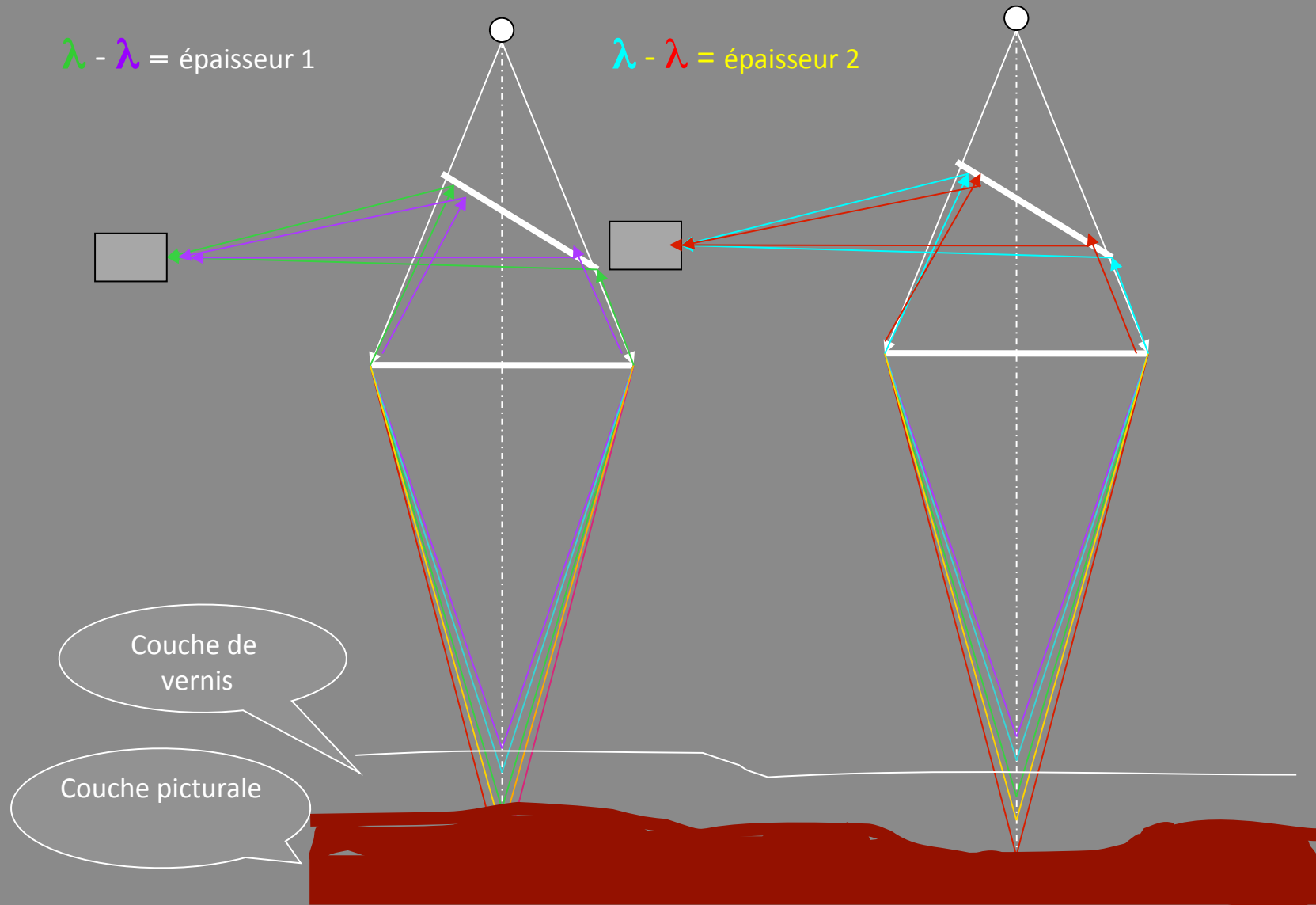
$\lambda - \lambda' = \text{épaisseur 1}$



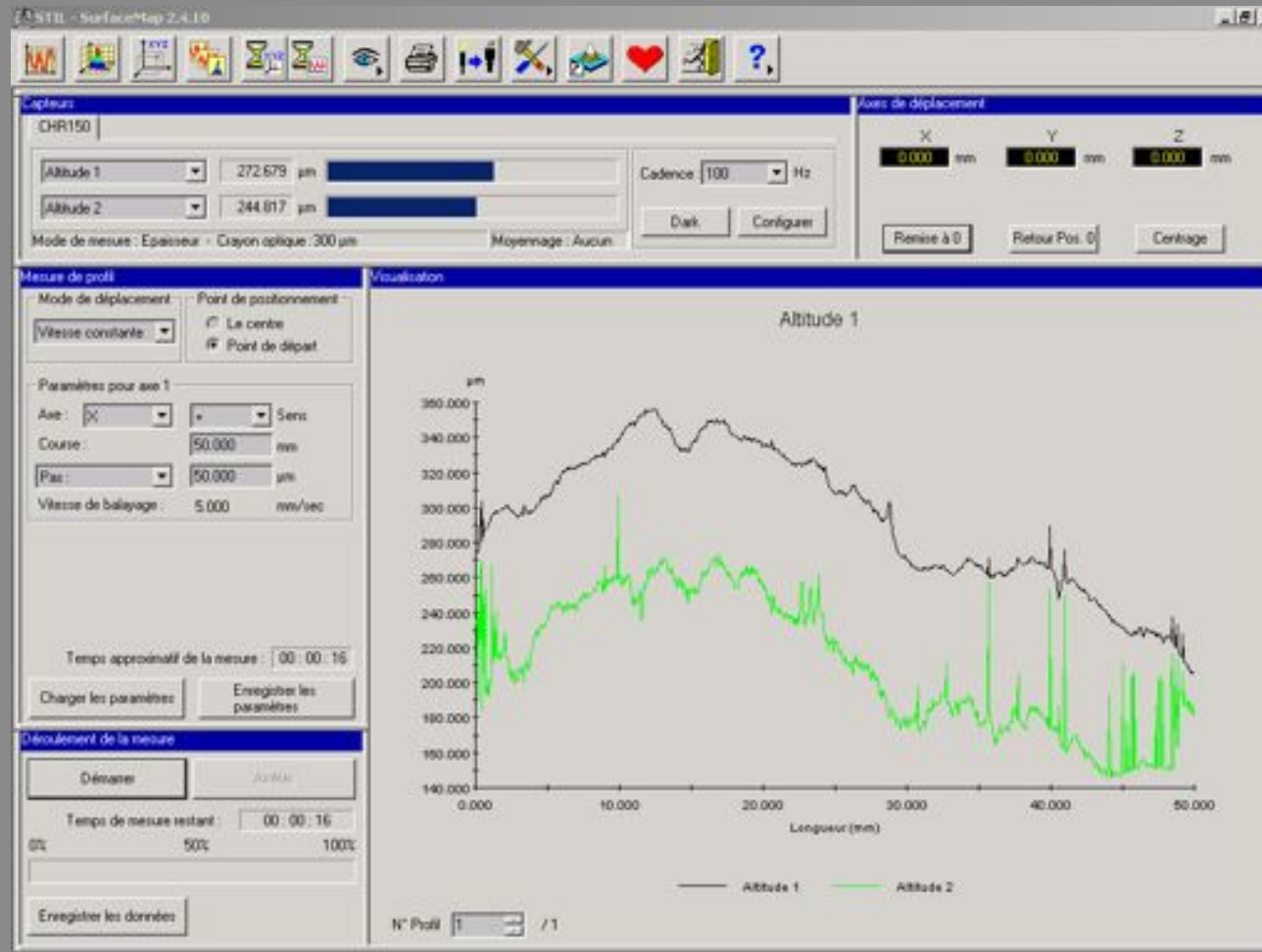
Thickness measurement

$\lambda - \lambda = \text{épaisseur 1}$

$\lambda - \lambda = \text{épaisseur 2}$

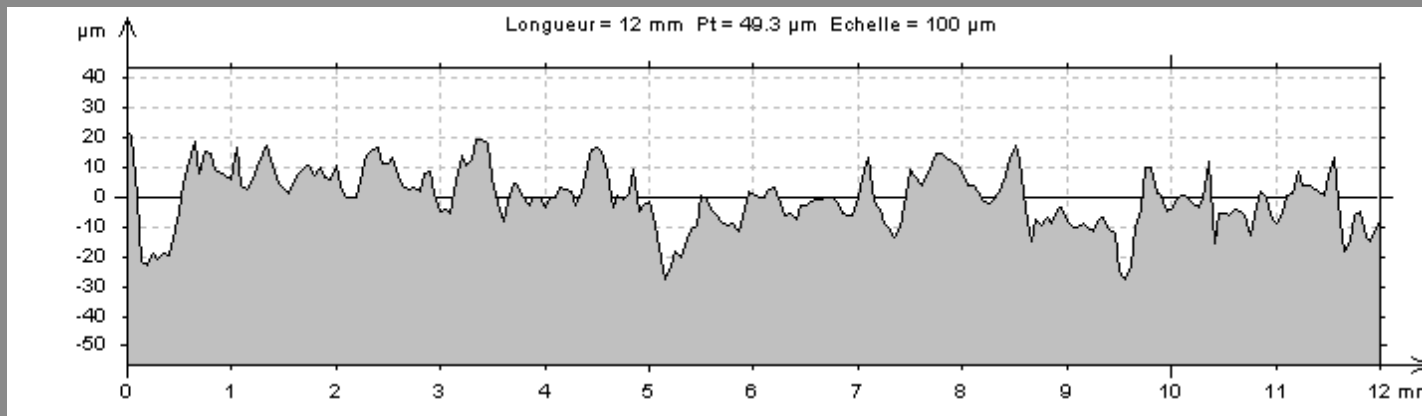


Thickness measurement



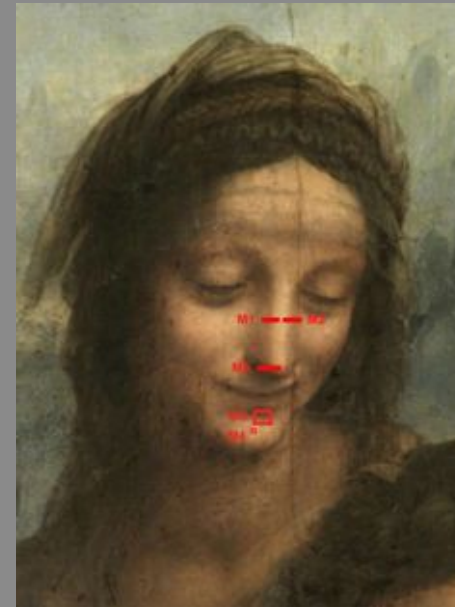
thickness measurement of a varnish layer

Generally the thickness of a varnish layer is about $50\mu\text{m}$. For this thickness value, the choice of a sensor of short field is obvious. We choose a sensor with a field of $200\mu\text{m}$ and measurement is made every $100\mu\text{m}$ on a length of 12mm . The results confirm expectation, the medium value being close to $50\mu\text{m}$



Thickness of a varnish layer

Probe locations: measurement done before conservation



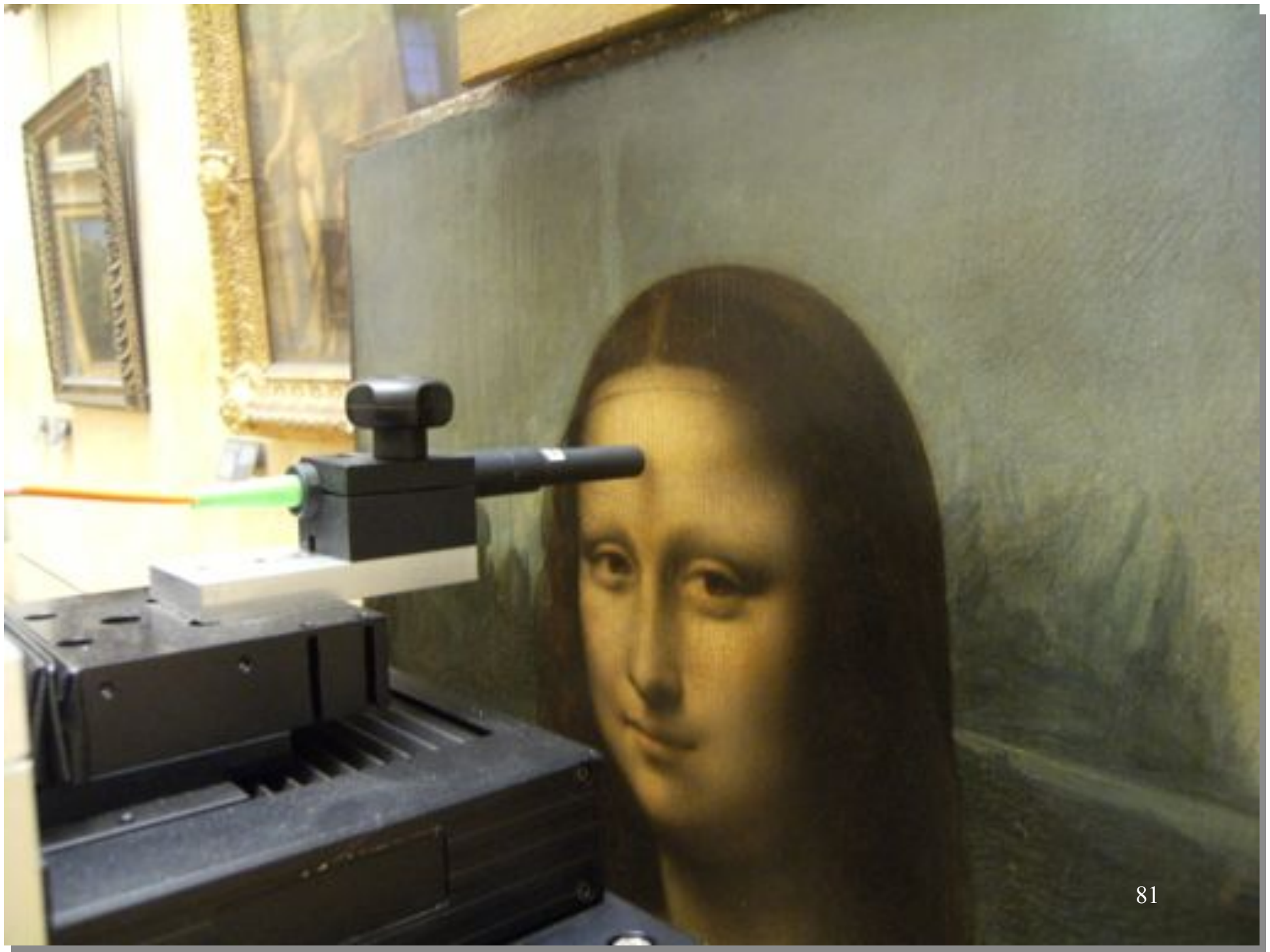
Results



Pointés	M1	M2	M3	M4	M5	M6	M7
Mesures	30 μ m	30 μ m	21 μ m	27 μ m	30 μ m	51 μ m	30 μ m

mean thickness 30 μ m

Deviation +/- 25%



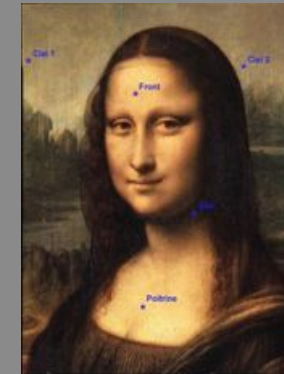
Other Leonardo's works



30 μm



100 μm



48 μm

Mean values according to a varnish refractive index of 1.7.

System in situ.





Mobile Laboratories



CHARISMA

**Cultural Heritage Advanced
Research Infrastructures:
Synergy for a Multidisciplinary
Approach to Conservation**



21 Research Infrastructures
11 Countries

3 Networking Activities
3 Access Activities

1120 access days planned

3 Joint Research Activities

EC contribution: 7,6 ML

Duration: 4 years



Coordinator:

University of Perugia - Italy

MOLAB equipment

laser profilometer

IR-scanner

microDrilling

UV-vis fluo imaging

UV-vis abs

UV-vis fluo punctual

NMR-Mouse

microRaman

mid-FTIR

XRF



0 2 4 6 8 10 12 14 16

Transnational access



MOLAB

A Mobile Laboratory with 15 instruments that can be chosen the users for *in-situ* measurements



Transnational access

...a set of 15 portable equipments is offered by a joint group of infrastructures, under a coherent management, for *in-situ* non-invasive investigations without movement of the object nor sampling...

Techniques: -XRF and UV-Vis spectroscopy;

-mid- near-FT-IR;

-XRD;

-Raman (micro- or macro-);

-fluorescence emissions (wavelength and time-resolved..);

-multispectral imaging (from Vis to IR);

-others...(NMR profiler..)



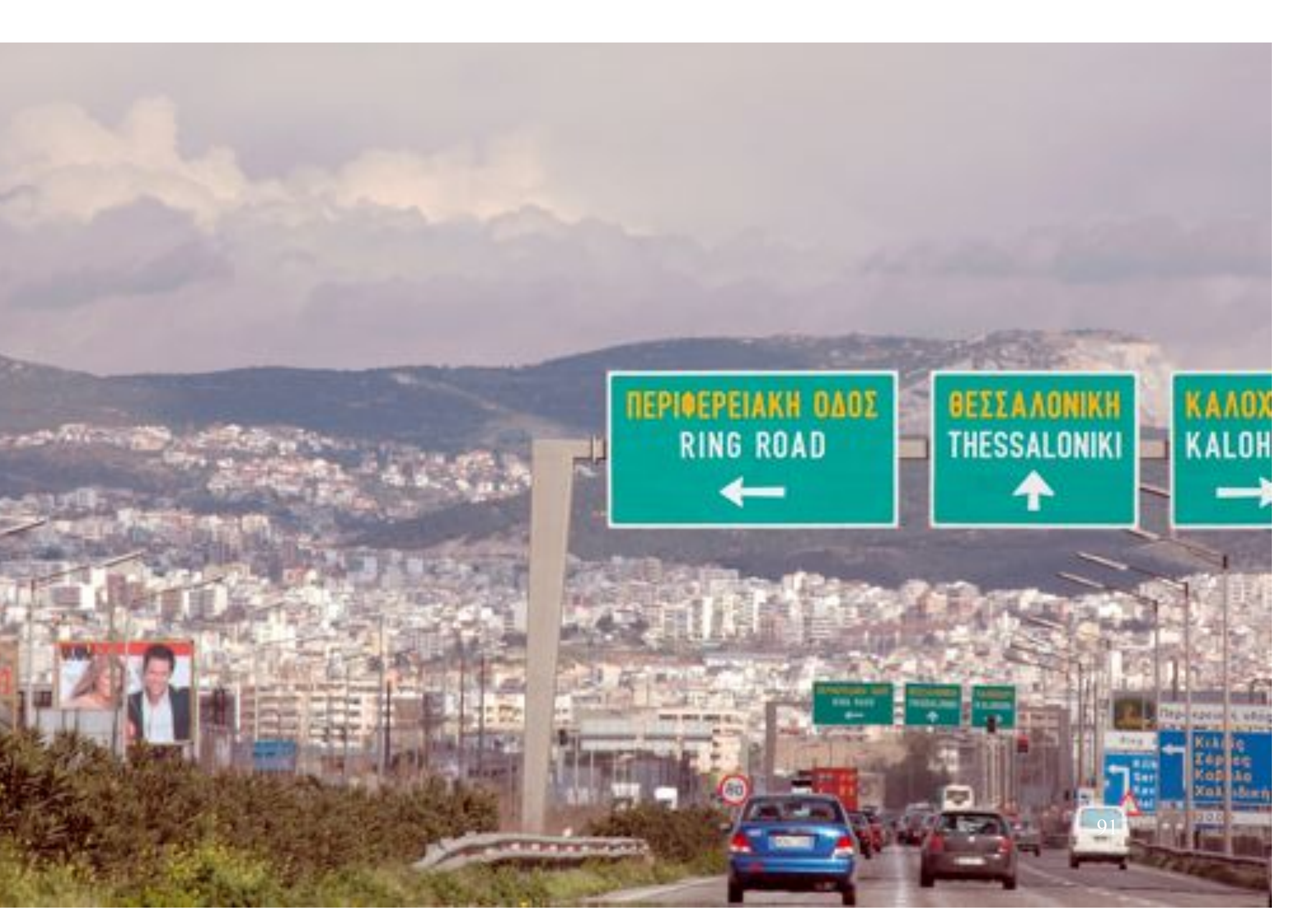
Expected users: -conservation scientists developing on materials and methods in restoration..;

-conservator-restorers carrying out experimentation on cleaning techniques on a specific artwork ...;

-curators that want to exploit the MOLAB facilities to study underdrawings (paintings) or execution techniques in paintings, ceramics, sculptures, etc....







ΠΕΡΙΦΕΡΕΙΑΚΗ ΟΔΟΣ
RING ROAD
←

ΘΕΣΣΑΛΟΝΙΚΗ
THESSALONIKI
↑

ΚΑΛΟΧΟΡΙ
ΚΑΛΟΧΟΡΙ
→



Painting by E.Munch in the aula of the Oslo University.

Group leader: Tine Froysaker, *Oslo University*



Fig. 1 Water tide-line in *The Fountain* in normal light



Fig. 7 Delaminations between canvas and Masonite in *The Fountain*

- XRF
- fiber-optic Vis-NIR
- VIS multispectral imaging
- fluorescence time-decay
- NMR depth-profiling

- fiber optic mid-FT-IR
- integrated XRD/XRF
- NIR multispectral imaging
- micro-Raman
- digital microscopy

- fiber optic near-FT-IR
- UV-Vis fluorescence spectrosc.
- fluorescence imaging
- bulk NMR relaxometry¹
- AFM

Towards a material history of the Ghent Altarpiece

Group leader: Anne Van Grevenstein-Kruse, *University of Amsterdam*

MOLAB's interventions will focus on the four large panels in the polyptych's central zone, which will be temporarily dismantled in September/October). It concerns: 1. *God the Father/Christ* (210.5 x 80 cm); 2. *The Virgin Mary* (166.8 x 72.3 cm); 3. *St. John the Baptist* (162.2 x 72 cm); 4. *The Adoration of the Lamb* (134.3 x 237.5 cm).



- XRF
- fiber-optic Vis-NIR
- VIS multispectral imaging
- fluorescence time-decay
- NMR depth-profiling
- fiber optic mid-FT-IR
- integrated XRD/XRF
- NIR multispectral imaging
- micro-Raman
- digital microscopy
- fiber optic near-FT-IR
- UV-Vis fluorescence
- fluorescence imaging
- bulk NMR relaxometry
- AFM

The Last judgement Triptich by Hieronymus Bosch (Academy of Fine Arts, Vienna, Austria)

Group leader: Renate Trnek,
Academy of Fine Arts, Vienna



The Last Judgement Triptych by Hieronymus Bosch in the Gemäldegalerie der Akademie in Vienna

- XRF
- fiber-optic Vis-NIR
- X VIS multispectral imaging**
- fluorescence time-decay
- NMR depth-profiling

- fiber optic mid-FT-IR
- integrated XRD/XRF
- X NIR multispectral imaging**
- micro-Raman
- digital microscopy

- fiber optic near-FT-IR
- UV-Vis fluorescence
- X fluorescence imaging**
- bulk NMR relaxometry
- AFM

Analysis of silver-based reliquaries of the St Maurice Abbey Treasure (CH)

Group leader: Denise Witschard,
Abbaye de St Maurice, CH

The elementary analysis will make it possible to precise the nature of the base metal (gilt (or not) silver based alloy, silvered copper-based alloy...) and apprehend the risks of side effects during the treatment.



Figure 4: Some tarnished masterpieces of the treasure of relics of Saint Maurice Abbey: a/ detail of the arm reliquary of Saint Bernard (end of the 12th century), b/ detail of the equestrian statue of Saint Maurice (1577) and c/ head reliquary of Saint Candide (1180).

The complementary structural analysis of corrosion products will enable to define the treatment parameters according to the artworks and their condition state.

- | | | |
|--|--|---|
| <input type="checkbox"/> XRF | <input type="checkbox"/> fiber optic mid-FT-IR | <input type="checkbox"/> fiber optic near-FT-IR |
| <input type="checkbox"/> fiber-optic Vis-NIR | <input type="checkbox"/> X integrated XRD/XRF | <input type="checkbox"/> UV-Vis fluorescence spectrosc. |
| <input type="checkbox"/> VIS multispectral imaging | <input type="checkbox"/> NIR multispectral imaging | <input type="checkbox"/> fluorescence imaging |
| <input type="checkbox"/> fluorescence time-decay | <input type="checkbox"/> micro-Raman | <input type="checkbox"/> bulk NMR relaxometry |
| <input type="checkbox"/> NMR depth-profiling | <input type="checkbox"/> digital microscopy | <input type="checkbox"/> AFM |

STARLAB

Cyprus Institute STARC
(institution financed by RPF –Research
Promotion Foundation
2012-2016

STARLAB Cyprus

Partners:

STARC-CyI (coord.)

UCy-ARU: Archaeological Research Unit

C2RMF, Fr

CNR-ISTM, University of Perugia, It

FORTH, Heraklion, Gr

STARLAB Cyprus

Mobile lab with facilities for digital data acquisition, geophysics, data processing and archaeometry, for research, conservation and preservation of CH.

4-wheel drive truck with designed cabin

a) Chemical and physical analyses:

XRF (X-Ray Fluorescence): Bruker ARTAX 200 (already owned by HO)

Spectro Colorimeter: STIL RUBY

Digital 3D videomicroscope: Hirox KH-8700

b) 2D and 3D digital data acquisition

Digital camera with accessories: Nikon D3X, with optics and tripod

Lighting system

3D scanner (close range): Breuckmann SmartScan3D

3D scanner (long range): Leica HDS6000

c) Surveying

Total station: Leica TPS 1200+

Differential GPS: Leica ScanRover integrated with Total Station

d) image processing (IR and UV photography)

Multi Spectral Camera: MUSIS MS (already owned by HO)

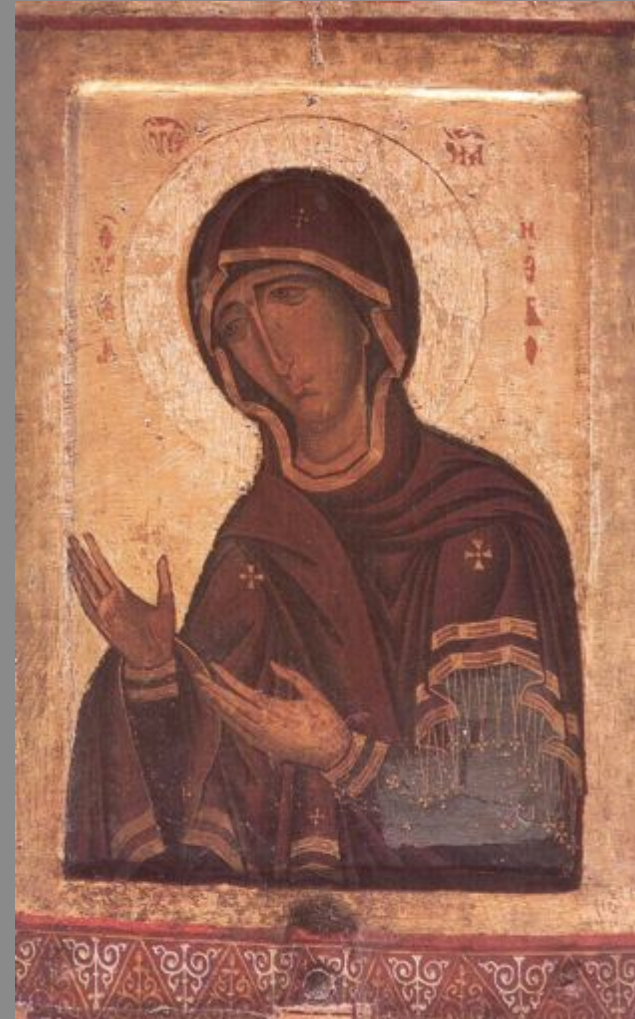
e) Geophysics for survey

STARLAB



A BYZANTINE ARTIST UNVEILED
Icons of Theodore Apseudis in Cyprus

“Encleistra” (Cave-cell) of St. Neophytos, Paphos



Equipex Patrimex



Equipex

R&D

Research on CH artefacts:
knowledge and preservation

Laser platform

Mobile platform

Cleaning, Conservation
Spectroscopy
Laser/Matter interaction

PUMA/ Soleil

IRAMIS Platform CEA
A. Semerok (DEN/DSM)

Coupled tomography and et Laser analysis

Laser platform

Mobile platform

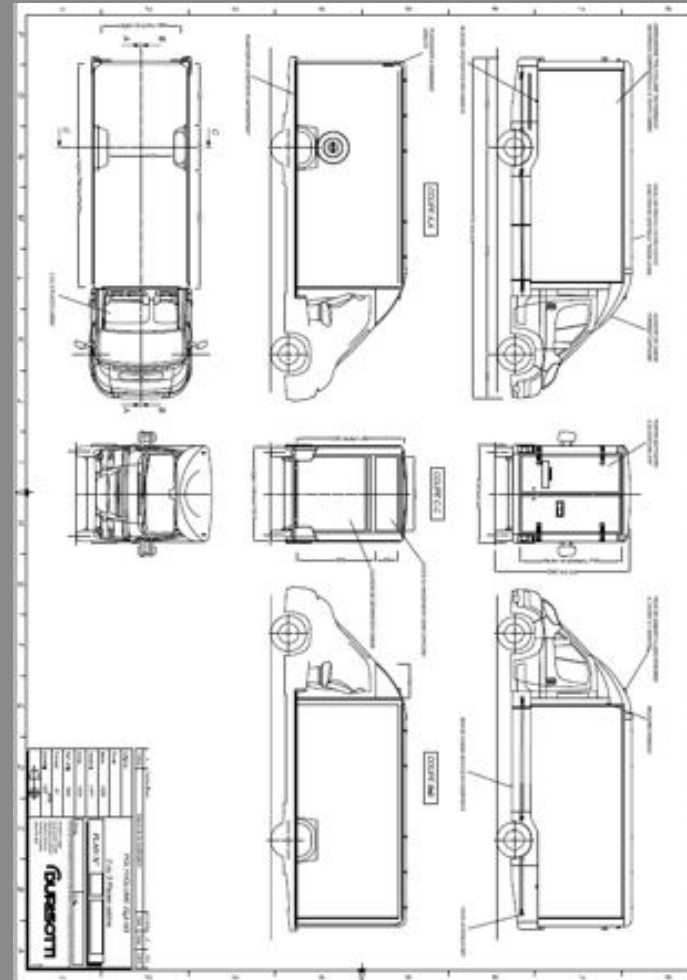
Cleaning, Conservation
Spectroscopy
Laser/Matter interaction

PUMA/ Soleil

IRAMIS Platform CEA
A. Semerok (DEN/DSM)

Coupled tomography and et Laser analysis

Equipex mobile platform



Portable LIBS LIF RAMAN





Musée Unterlinden



Abbaye de St Savin



Château de Oiron



Cathédrale Notre Dame de Paris



Cathédrale de Strasbourg



Villeneuve-lez-Avignons
monastery



Thank you for your attention

Michel Menu, C2RMF
michel.menu@culture.gouv.fr

Workshop on Portable X-ray Analytical Instruments for Cultural Heritage
ICTP, Trieste, 29 April 2013 – 3 May 2013