Photonics for Heritage Science. Expanding the infrastructure, widening synergies

Paraskevi Pouli

Photonics for Heritage Science, IESL-FORTH, GR

12th FORTH RETREAT 2022

PhoHS.iesl.forth

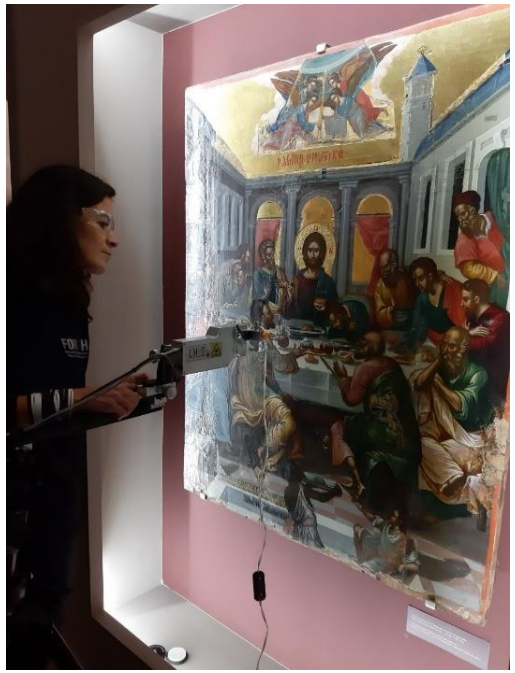
LaserArtFORTH

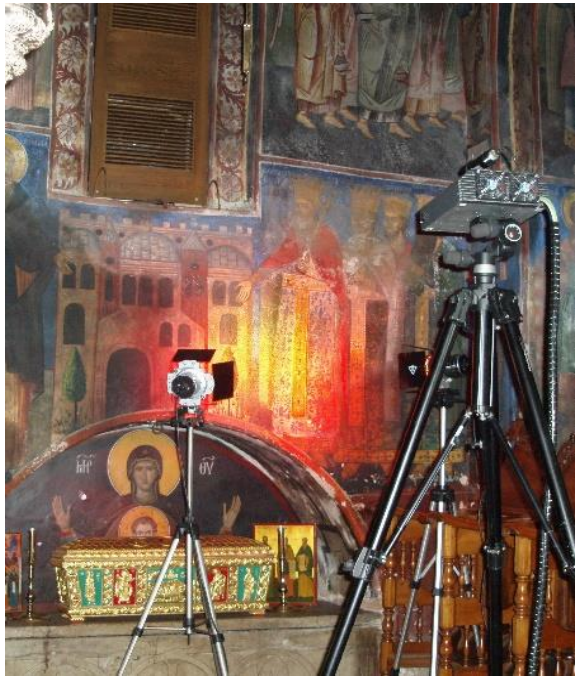
Photonics for HERITAGE SCIENCE

FORTH FOUNDATION FOR RESEARCH AND TECHNOLOGY - HELLAS

Photonics for Heritage Science @ IESL-FORTH; a 30 years story

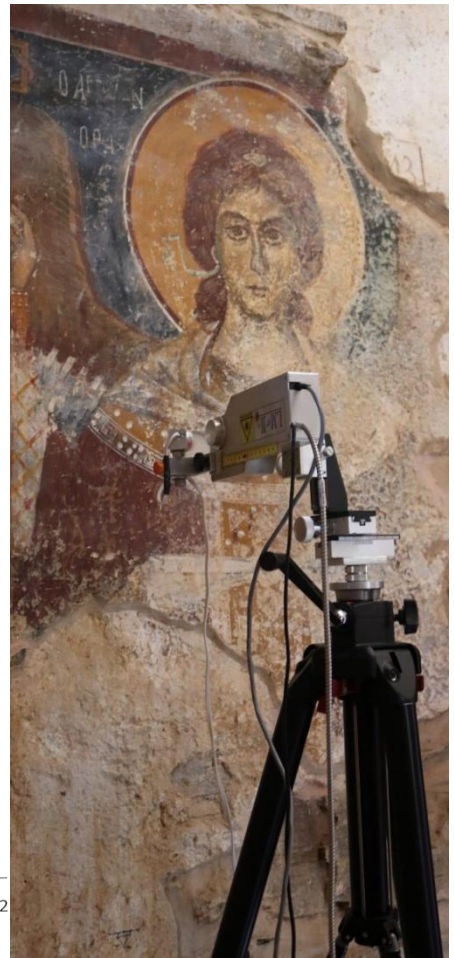
- Over the past 30 years, **PhoHS** has pioneered the research and development of advanced laser systems and technologies in analysis, diagnosis and conservation of cultural heritage.






Photonics for Heritage Science @ IESL-FORTH; a 30 years story

Development of analytical and diagnostic methodologies and portable instruments to bring innovative research into the Museums, the conservation studios and on-site







Photonics for Heritage Science @ IESL-FORTH; a 30 years story

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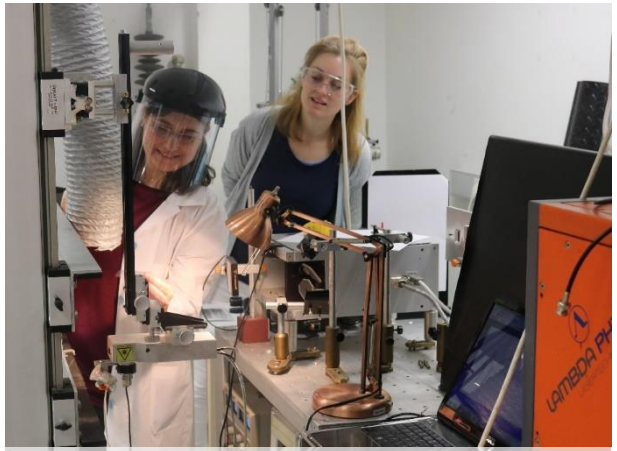
St John, Episkopi, July 2021

Museum of Christian Art
"St. Catherine of Sinai", Nov 2021

European Research Infrastructure in Heritage Science

Active participation in the ULF-facility of LaserLab Europe Research Infrastructure (RI), operating at FORTH successfully for the past 30 years.

Since 2009, PhoHS is a key member of the RI projects CHARISMA, IPERION-CH and IPERION-HS and the networks E-rihs.eu (ESFRI roadmap), having a core role also in its Greek node E-rihs.gr



FIXLAB/ IPERION CH, 2017

MOLAB/ Knossos, 2019

MOLAB
Mobile instruments for in-situ diagnostics

The **MO**bile **LAB**oratory allows users to access state of the art mobile instrumentation for the study and diagnosis of valuable or immovable objects, archaeological sites and historical monuments.

FIXLAB
Access to advanced laboratories

The **FIX**ed **LAB**oratory provides access to leading infrastructures for sophisticated scientific investigations on samples or whole objects.

DIGILAB
Digital documentation and management

The **DIGI**tal **LAB**oratory allows users to exploit advanced databases for the documentation of their research and the handling of their data.

Laser cleaning at IESL-FORTH… 30 years of research & applications

A 30 year magnificent journey of IESL-FORTH!

1994
1st attempt to remove aged varnish layers and dark soot deposits from a byzantine wooden icon using an ultraviolet excimer laser beam at 248nm

2001-2009
West Parthenon Frieze:
Removal of dark pollution crust from marble

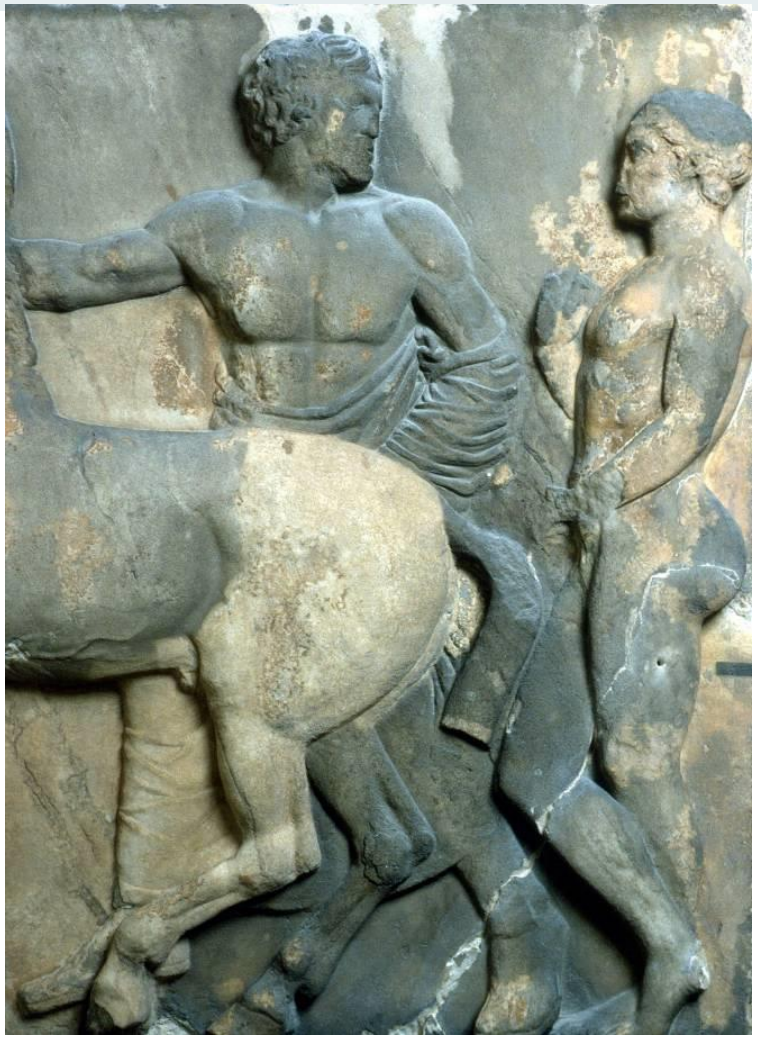
2011-2021
Acropolis Museum:
In-situ laboratory open to the public
IIC 2012 Keck Award

2001
1st on-site laser cleaning of burial crust from marble sculpture
Hermes, Ancient Messene

2008-2010
Prostasis of Erechtheion:
Removal of pollution crust from marble

Phase 1: moving on-site
Laser cleaning the Parthenon West Frieze

- **2000-2002:** the 2-wavelength laser cleaning methodology was proposed and developed
- A dedicated transportable laser system was built to fit to the needs of the specific cleaning challenge
- **2002-2005:** Laser cleaning of the West Frieze of the Parthenon
- **2005-2009:** Laser cleaning of sculptures such as the Northern and Eastern Parthenon metopes and the Frieze of the Temple of Athena Nike.



West Parthenon Frieze (block 3)

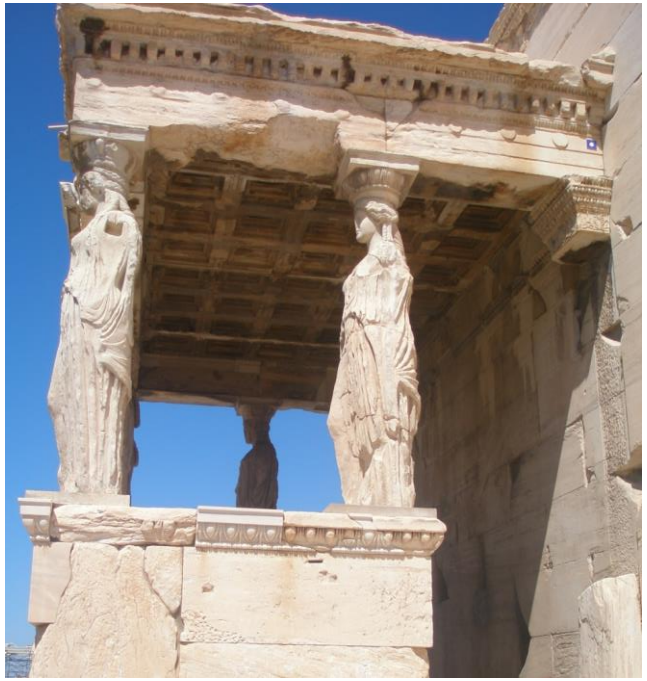
GR1004453B-2002

Pouli et al, Heritage Science, 2016
Pouli et al, Springer Proceedings in Physics 100, 2005

In collaboration with

Phase 2: moving outdoors
Laser Cleaning the Caryatids porch coffered ceiling, Erechtheion prostasis

- Transferring the technology **outdoors**
- Complicated intervention **topography**
  - ⇨ Significant height
  - ⇨ Deep indentations
- **Laser safety** and cleaning measures
  - ⇨ Blockage of the laser beam
  - ⇨ Extraction to collect ablation particles
- Rougher **environmental** conditions
  - ⇨ high humidity during fall and winter
  - ⇨ extreme temperatures during summer, up to 40°C
- **Assessment** of the result
  - ⇨ portable microscopes, loupe lights



In collaboration with ΥΣΜΑ ΥΠΠΟ

Phase 3: open to the Public
The Acropolis Museum open laboratory

- Showcasing the laser cleaning of the Caryatids **to the public**
- **A specially designed platform** was developed by the Acropolis Museum,
  - ⇨ It "embraces" and isolates one sculpture at a time,
  - ⇨ it is moving in different heights
  - ⇨ It is robust and stable
- Laser safety and cleaning measures
- Assessment of the result
- **Communicating with the public**
  - ⇨ **Live streaming of the interventions**


IIC

Keck Award

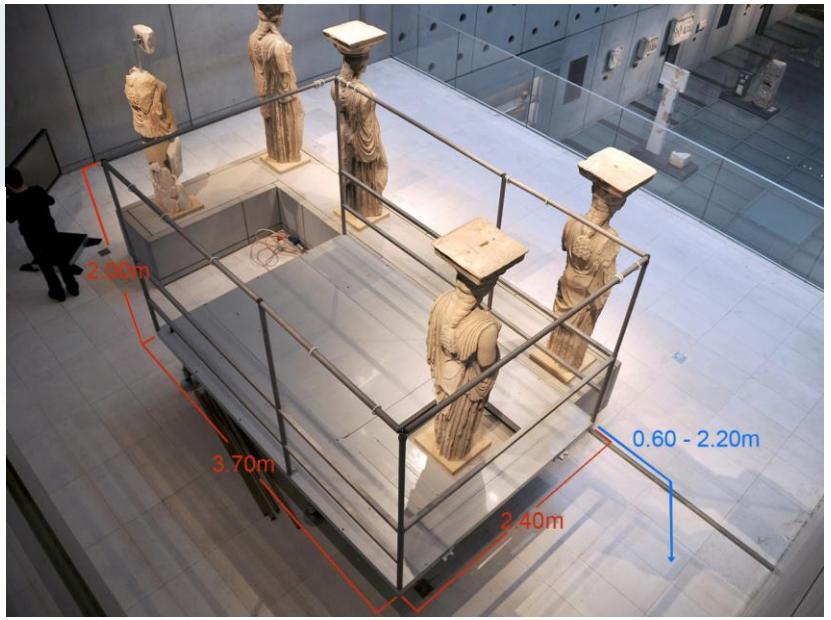
2012 Vienna Conference

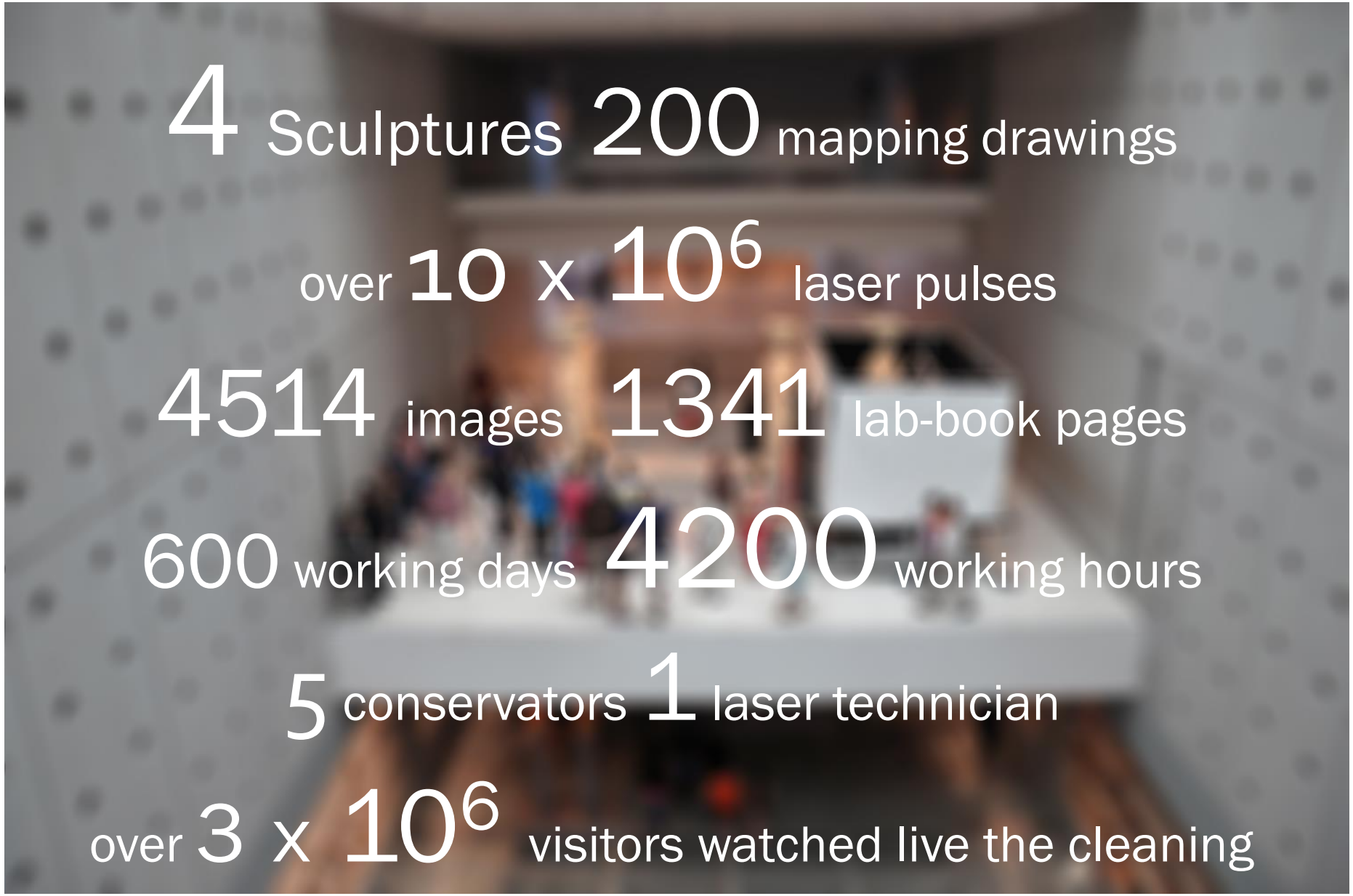
Awarded for the Acropolis Museum / FORTH project

'Laser rejuvenation of Caryatids opens to the public at the Acropolis Museum: A link between ancient and modern Greece'

Jerry Podany, *President*

Jo Kirby Atkinson, *Secretary-General*




4 Sculptures 200 mapping drawings
over 10 x 10^6 laser pulses
4514 images 1341 lab-book pages
600 working days 4200 working hours
5 conservators 1 laser technician
over 3 x 10^6 visitors watched live the cleaning

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MIS 5056208
CALLOS

2020-2023

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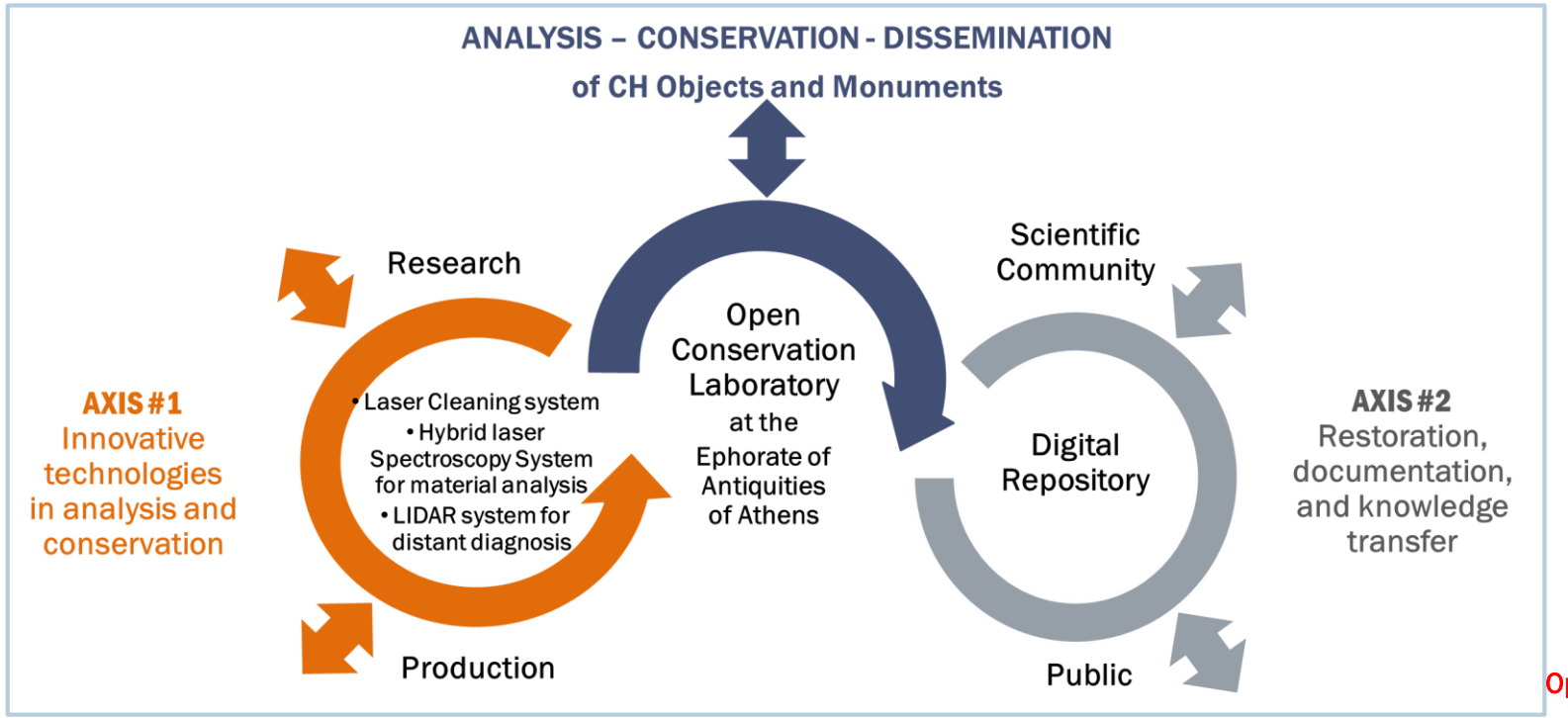
ΠΡΩΤΕΑΣ
OPEN–LAB

CALLOS

Conservation of Athens antiquities with Laser & LIDAR technologies Open to Science & public

- **CALLOS** aims at establishing an open-to-the-public conservation lab in the center of Athens at the premises of the Ephorate of Antiquities of Athens.
- A pioneering conservation workshop equipped with **innovative LASER diagnostic & conservation methods** and a **digital repository** for the effective handling and presentation of the produced data.

CALLOS*
@callosproject



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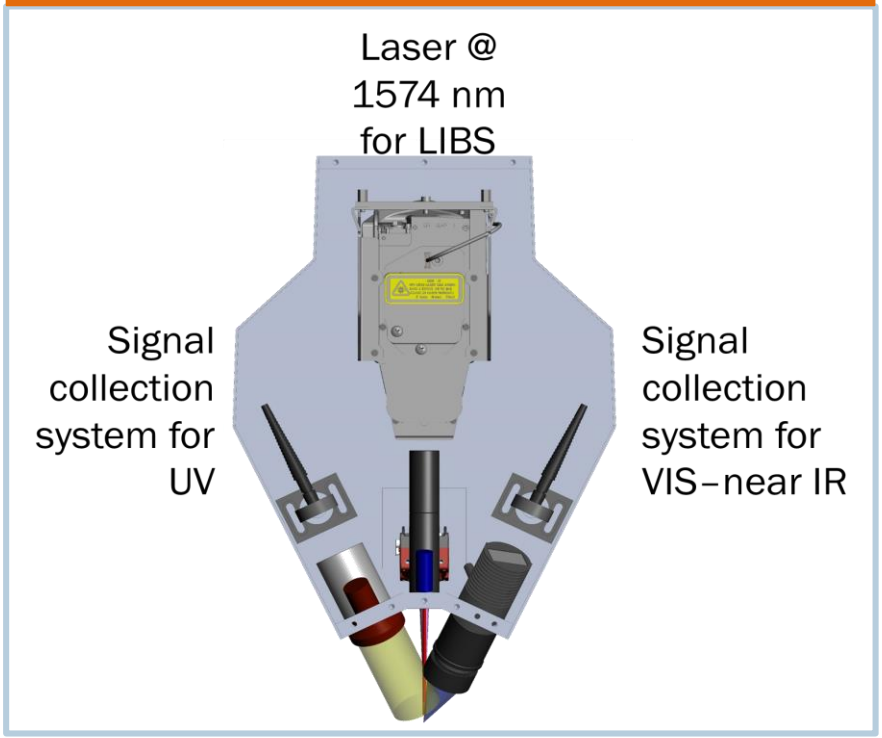
Conservation of Athens antiquities with Laser & LIDAR technologies Open to Science & public

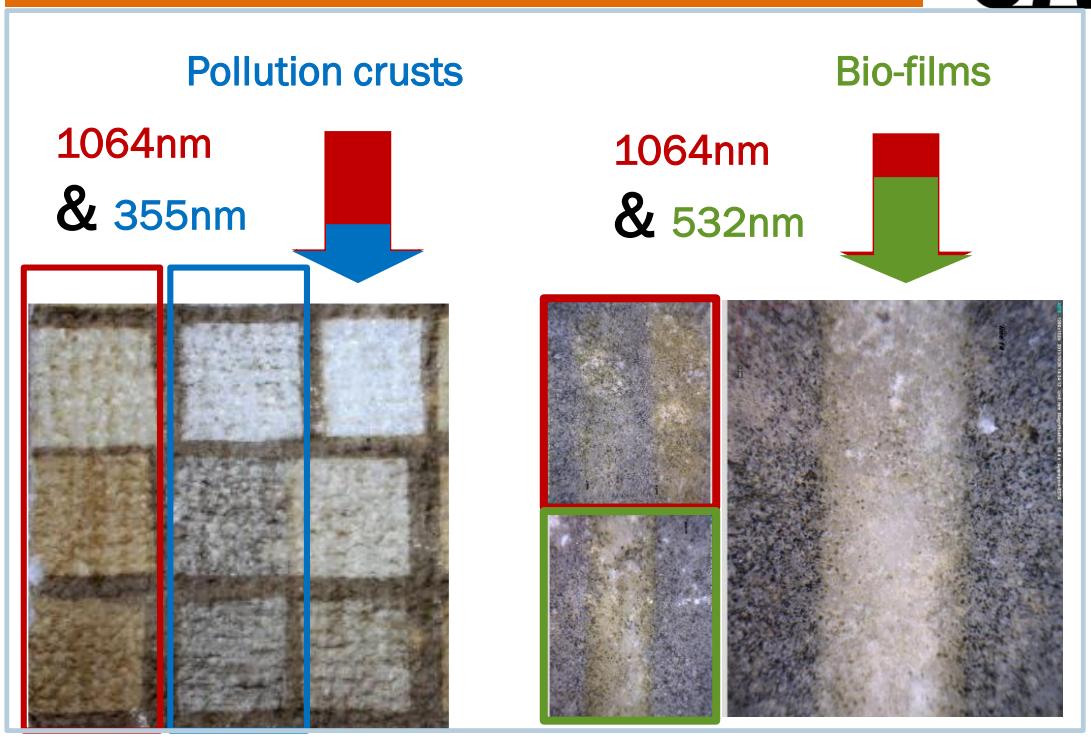
- 2 state-of-the art laser devices are developed within CALLOS to be installed in the dedicated open laboratory in the center of Athens.

CALLOS
@callosproject

Hybrid LIBS/DR/LED-IF analysis system



3-λ laser cleaning system



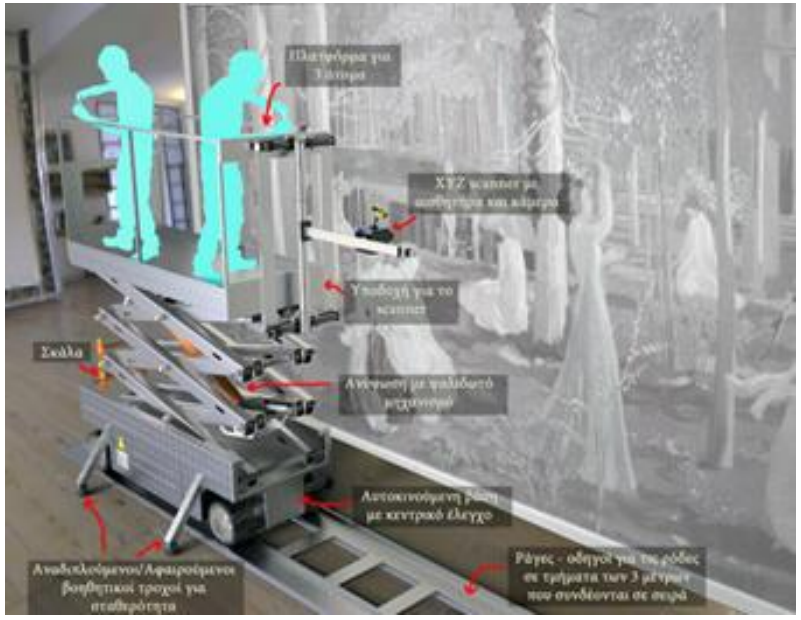
Open Innovation in Culture
2/2020-8/2023
MIS 5056208

PROTEAS

Advanced System for collection and management of analytical data for documentation and conservation of large-scale paintings in an open laboratory

- **PROTEAS** focuses at the development of an **Open-Access Workshop** (OAW) for large scale paintings within the premises of the National Gallery at Athens (NGA).

ΠΡΩΤΕΑΣ
OPEN–LAB



"**March 3, 1814**", by C. Muller (4.45 × 8.45 meters), NGA collection

"Research- Create - Innovate"
7/2020-7/2023
MIS 5069984
Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

Laser cleaning at IESL-FORTH… 30 years of research and applications

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Removal of acrylic over-paintings from oil paints

The "Imageless" exhibition
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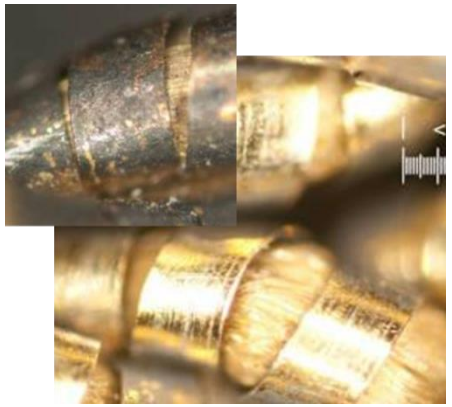

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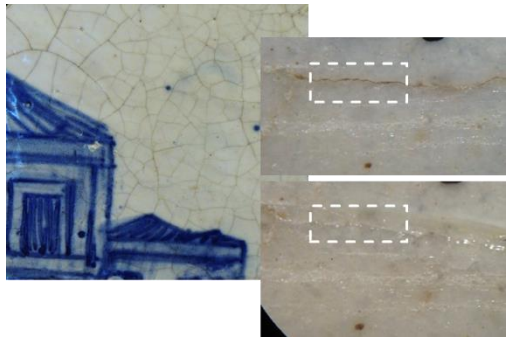
Archaeological Museum of Copenhagen

Removal of tarnish from gilded silver threads with silk core

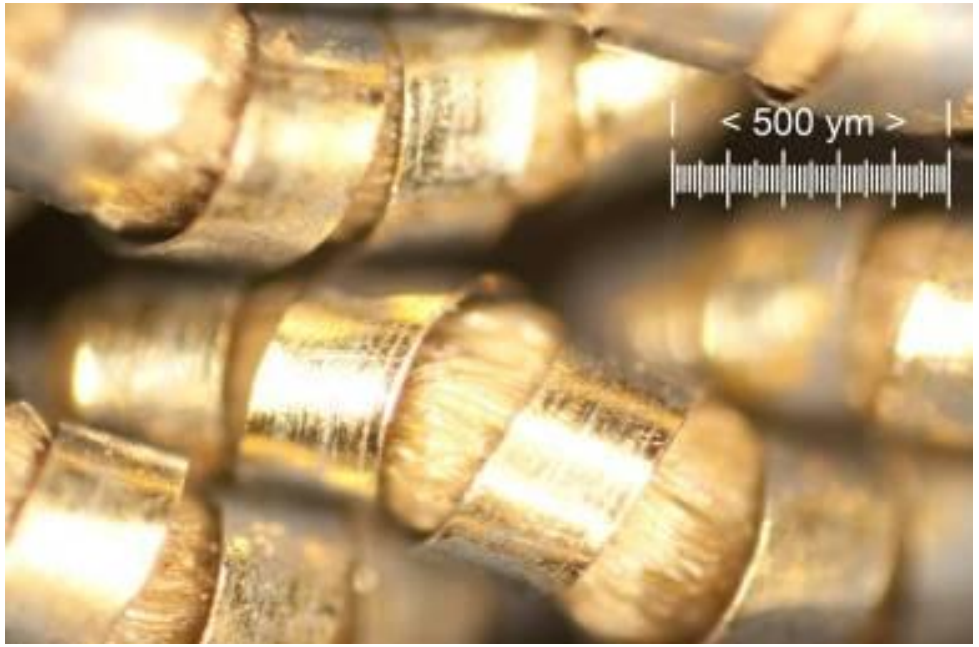


Laser-assisted removal of tarnish from gilded silver threads with silk core

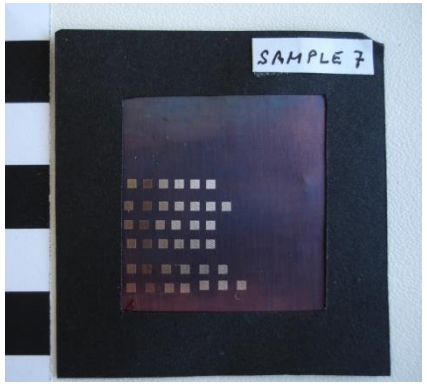
The cleaning challenge

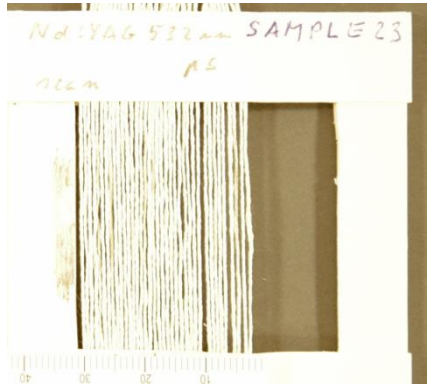
Combination of materials of fine thickness with different optical properties

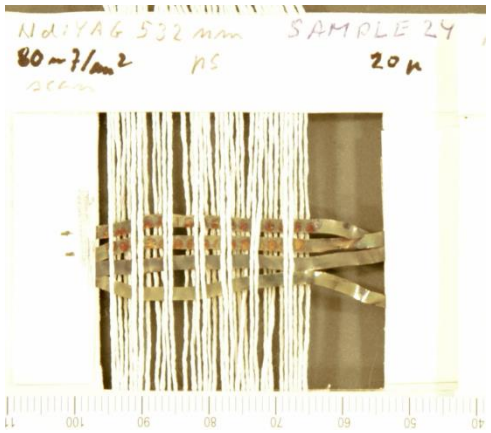
Thermal effects (i.e. melting of silver) must be avoided

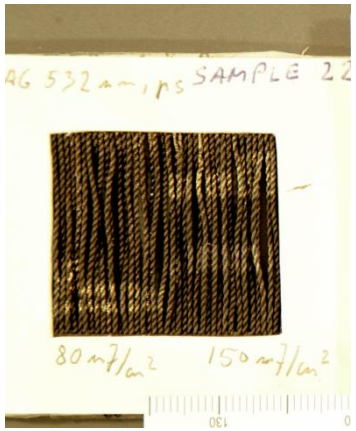


F= 80 J/cm^2 @ 532 nm, 150 *ps*





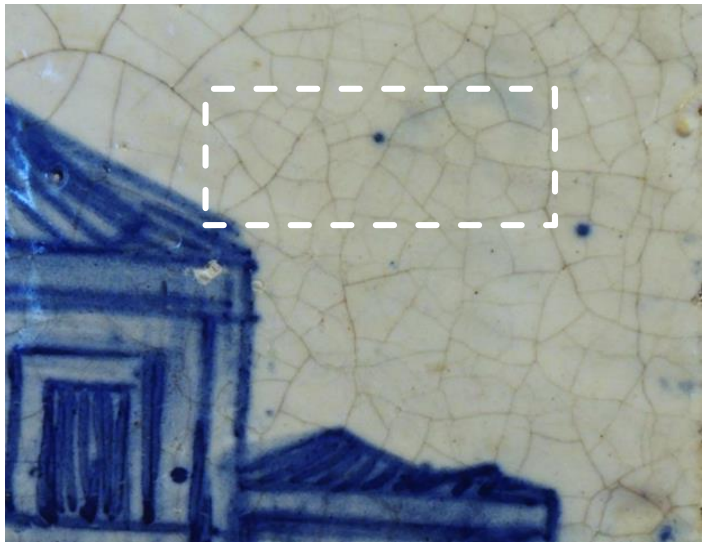




B. Taarnskov, P. Pouli, J. Bredal-Jørgensen, LACONA VIII Proceeding, 2011

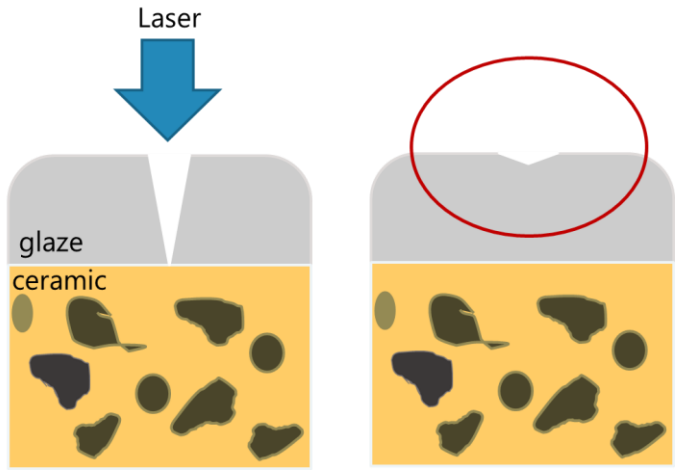
Laser-assisted mending of cracked historic glazed ceramic tiles

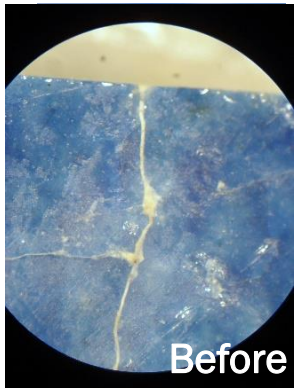
The restoration challenge → Is it possible to mend "*azulejo*" tiles on-site? → **Controlled thermal effects are essential**

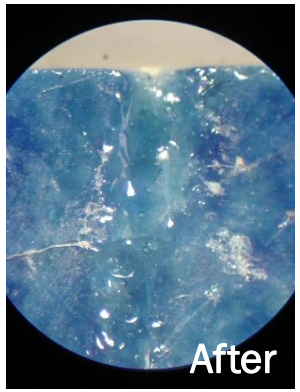


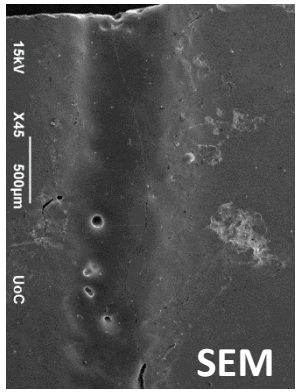
Using the thermal effects induced by a continuous CO_2 laser we substitute the firing of the glazed ceramics in an oven

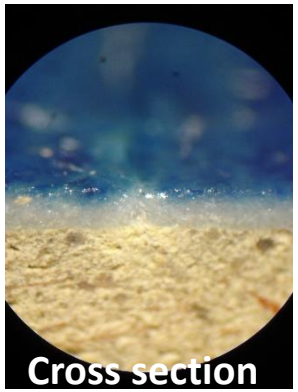
→ localised treatment of the pathologies (cracks, pin-holes etc.)

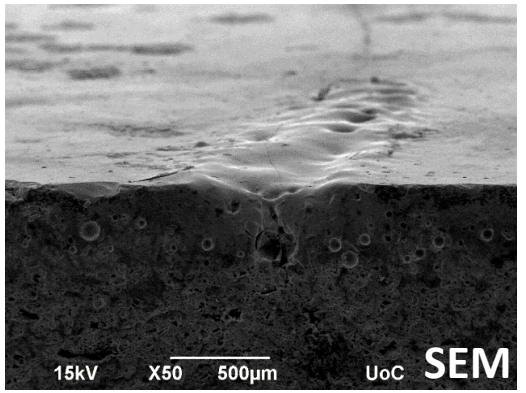












EP 3 429 975 B1,
Restoration of vitreous surfaces using laser technology,
K. Chatzigiannakis, P. Pouli, K. Melessanaki, M.E. Bernikola (FORTH, GR), J. M. Mimoso, S. R. Pereira (LNEC, PT),
19.01.2022 Bulletin 2022/03

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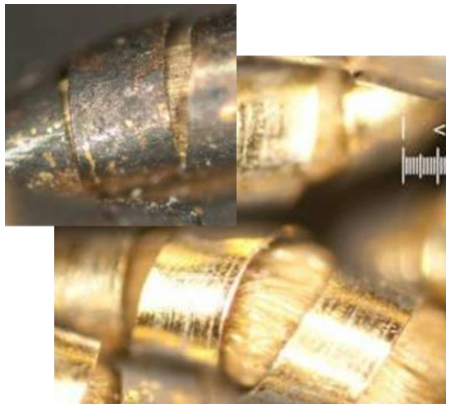

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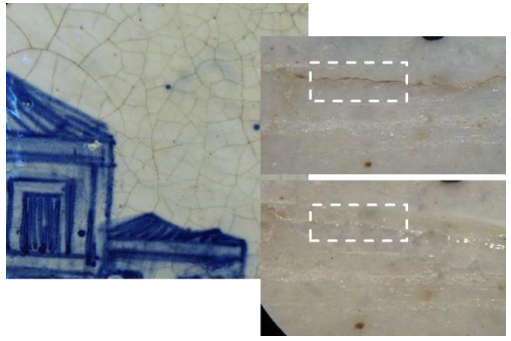

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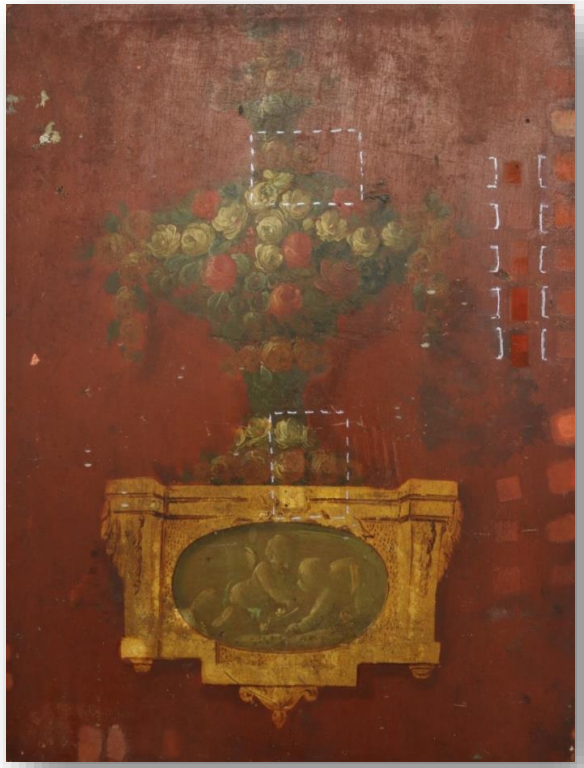
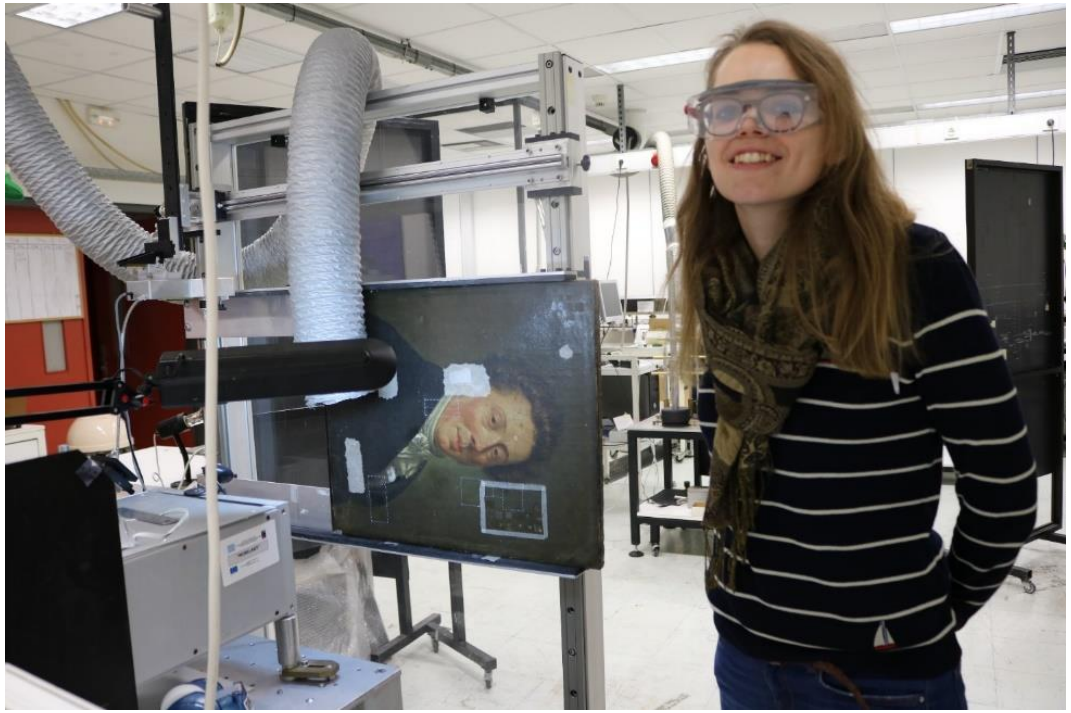


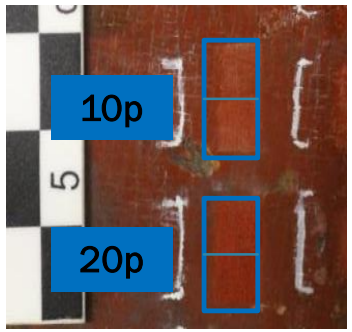


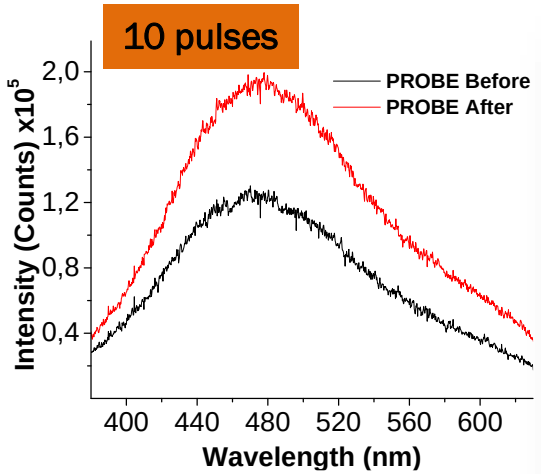
2017

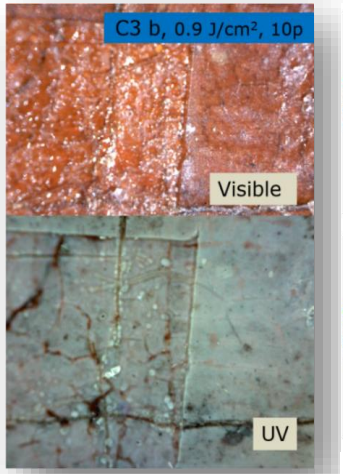
Diagnostic strategies for assessing the cleaning of paintings IPERION-CH (FP7 GA 654028)

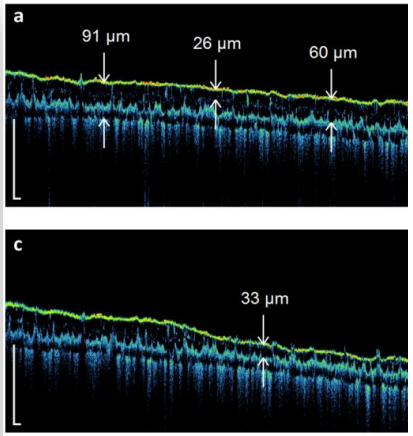
A number of paintings (18th - 20th Century) from the study collections of the **Cultural Heritage Agency of the Netherlands** and the **Rijksmuseum** were selected for a series of experiments as they present various layers of degraded varnishes and over-paints.

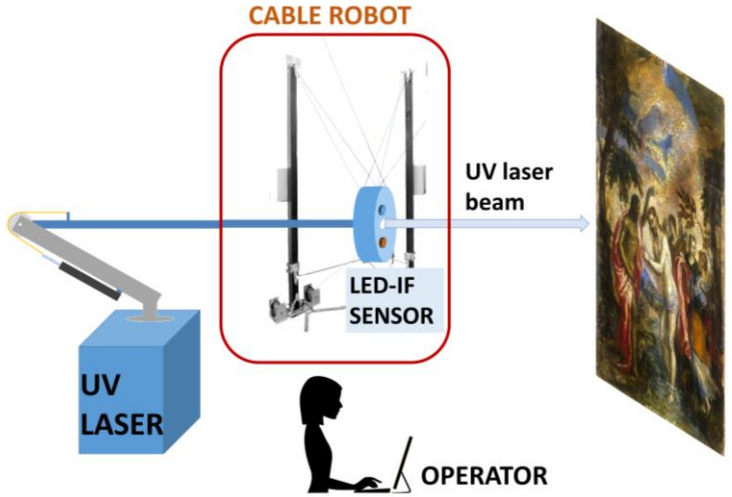
Monitoring laser-assisted removal of aged varnish layers from paintings with LIF spectroscopy



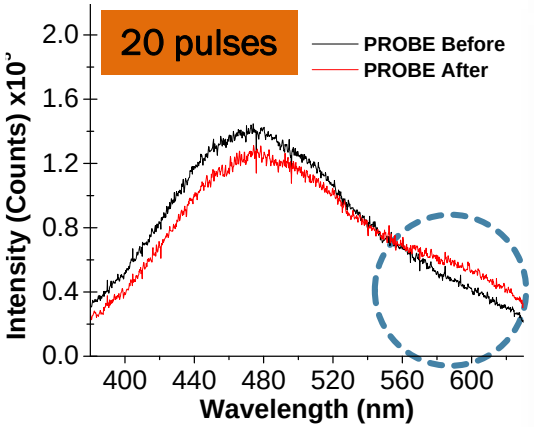


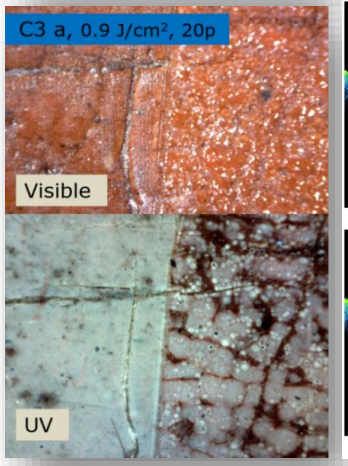


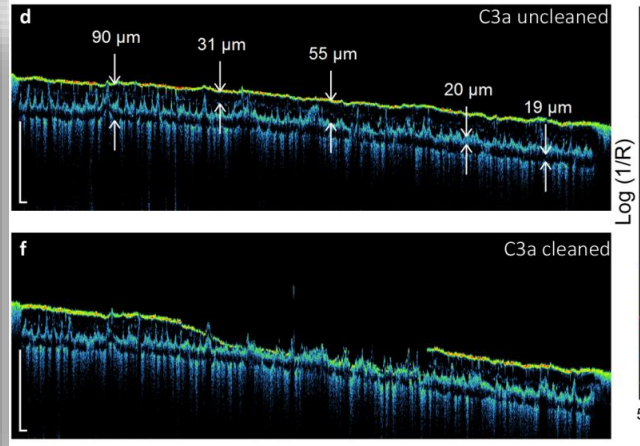


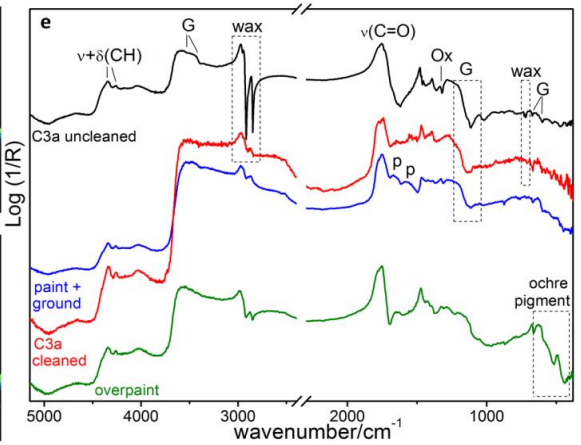


Different cleaning levels can be assessed and identified with LIF, as confirmed by complementary OM, OCT and FTIR analysis









Moretti P et al, Heritage Science, 2019
Kokkinaki O et al, Eur. Phys. J. Plus, 2021

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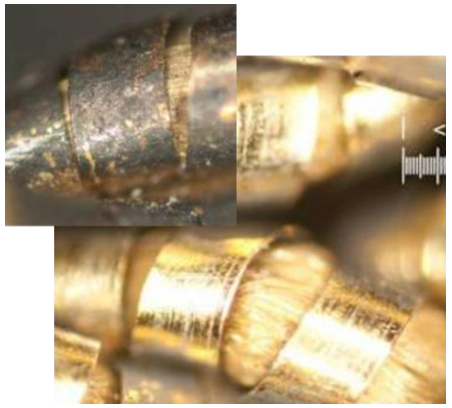

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2020

Photoacoustic monitoring of laser cleaning interventions;

Listening to the whisper of laser ablation

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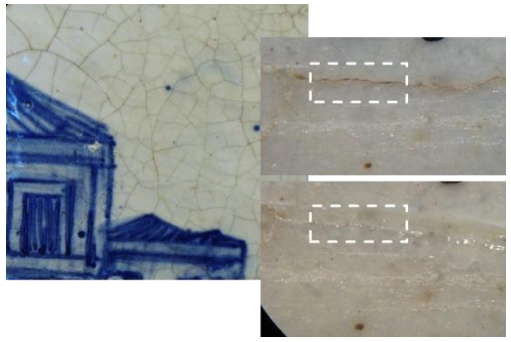

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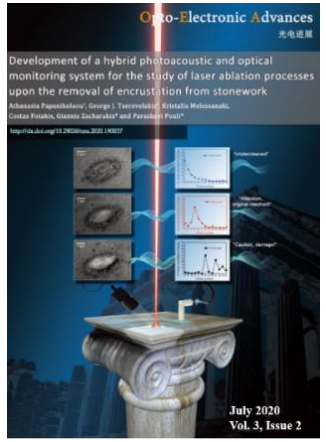
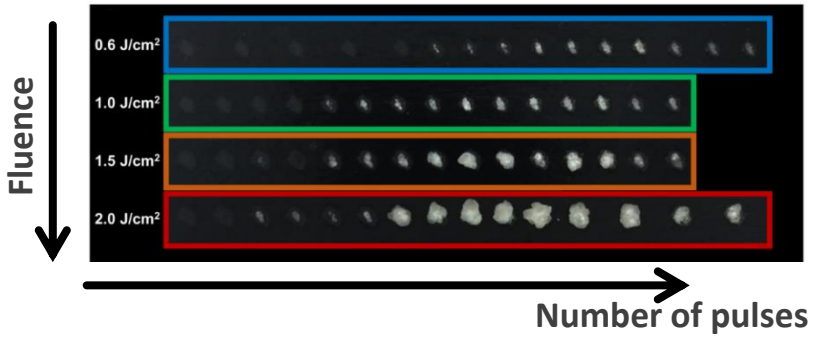
H2020 IPERION-CH

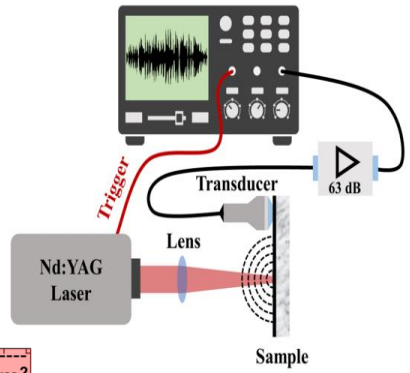
Monitoring laser-assisted removal of aged varnish layers from paintings with LIF spectroscopy



The whisper of light pulses; on-line photoacoustic monitoring of laser cleaning on stone

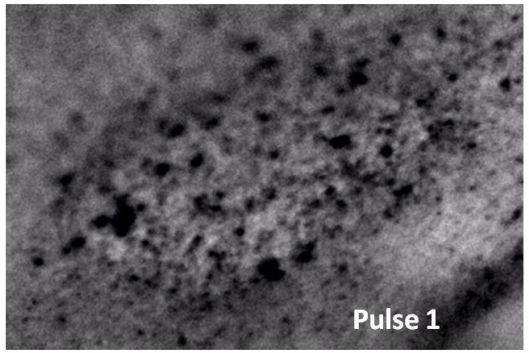
- **Developing the monitoring methodology and the PA system on marble mock-ups with graffiti paint**

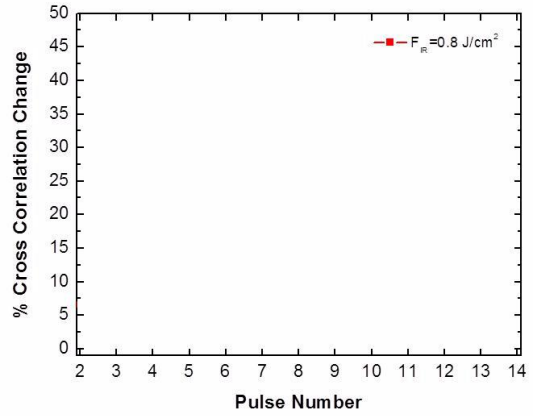


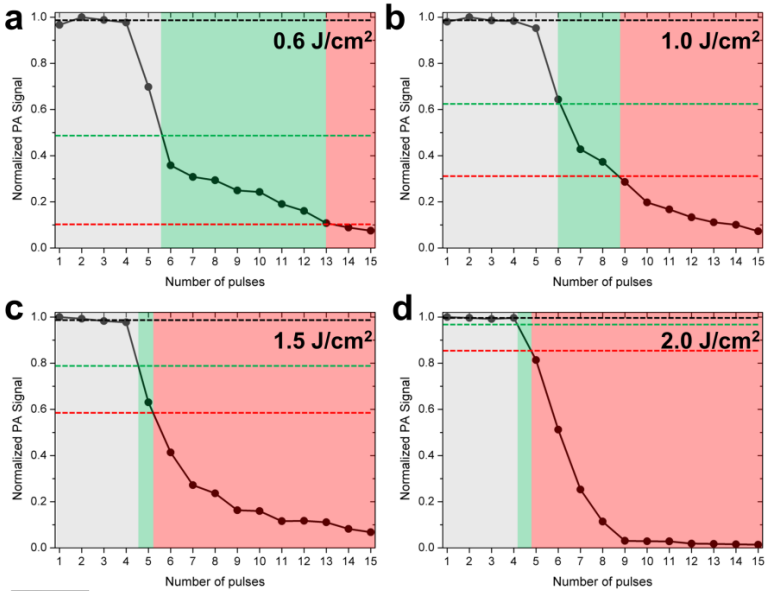


Determination of the laser pulse that removes the encrustation

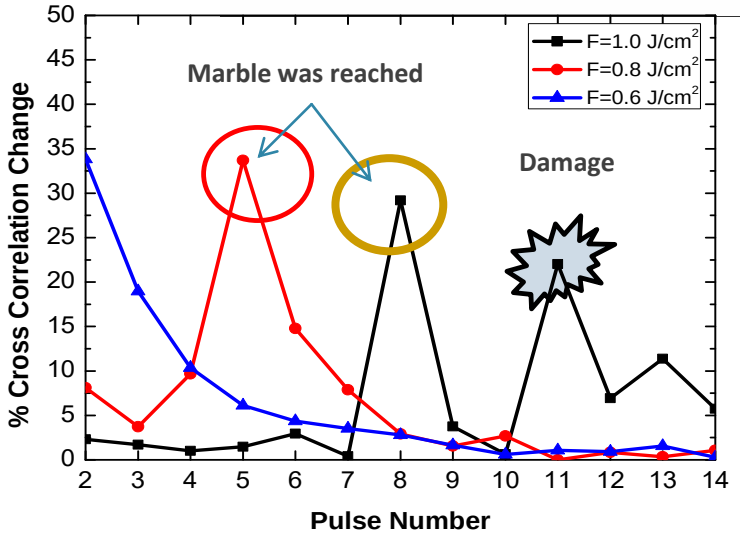
Irradiation with F=0.8 J/cm² at 1064nm







PA signal analysis predicts cleaning stages



Detection of optimum cleaning vs incomplete material removal and **over-cleaning** at 1064nm

Tserevelakis G et al, Heritage Science, 2020

Papanikolaou A et al, Opto-Electronic Advances, 2020

Tserevelakis G et al, J. Cultural Heritage, 2019

OPTO-CH summer school

opto-ch.iesl.forth.gr

OPTO CH training activities

The aim of **OPTO-CH** is to introduce participants to the applications of advanced laser-based technologies in HS



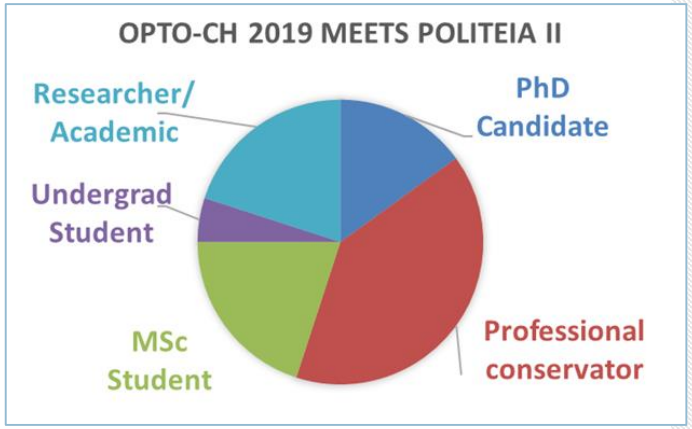


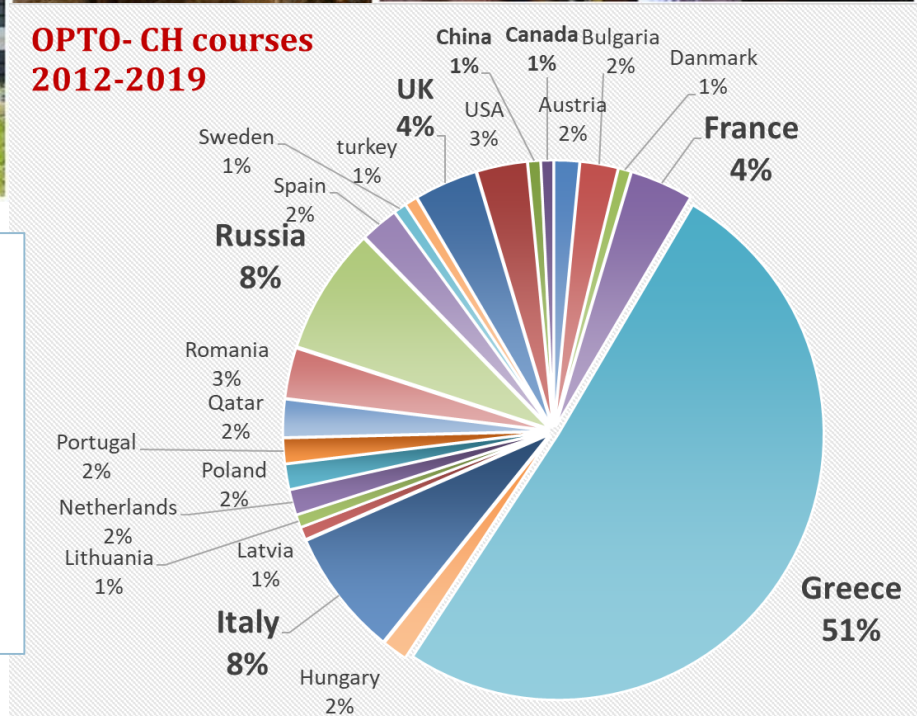






Lectures from experts on modern laser diagnostic, analytical techniques & laser cleaning methodologies are combined with practical demonstrations & laboratory hands-on sessions.
Field experiments on-site, at selected monuments in Crete, demonstrate the applicability of the techniques in practice.





China-Greece Belt and Road Joint Laboratory on Cultural Heritage Conservation Technology

2015: common actions to establish **NIKI,** a joint laboratory between China and Greece dedicated to novel laser methodologies addressing the most important challenges in analysis and cleaning of the objects exhibited at the Palace Museum. **NIKI** was established in 2017.

2020: Bilateral research collaboration between IESL-FORTH & the Palace Museum within the Chinese National Key R&D Program Project "**One Belt One Road: China-Greek Cultural Relics Protection Technology Joint Research**", with the aim to construct a joint laser laboratory at the premises of the Palace Museum in Beijing (2020-2023).

21 Dec 2021: Launching Ceremony for this Joint Laboratory Construction followed by a China-Greece Symposium on CH Conservation Technology held at the Palace Museum.

中国–希腊文物保护技术
"一带一路"联合实验室
CHINA-GREECE BELT AND ROAD
JOINT LABORATORY ON CULTURAL
HERITAGE CONSERVATION TECHNOLOGY

2016

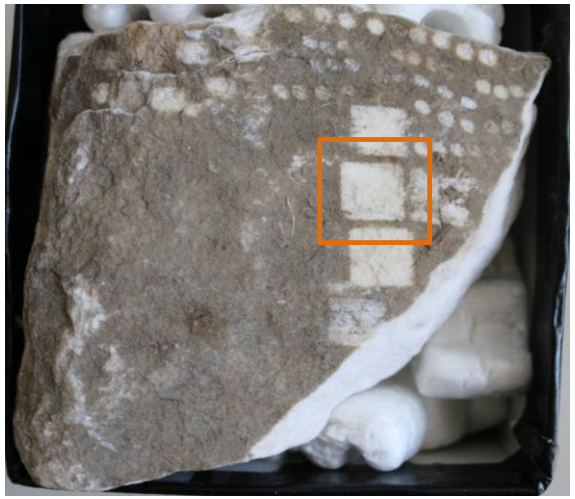
2017

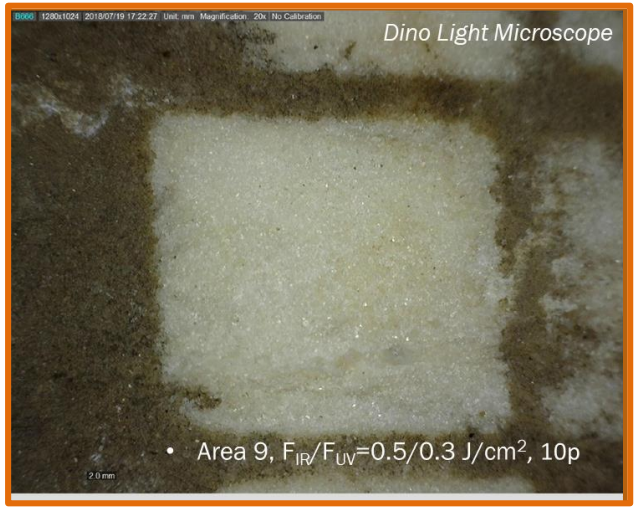
2018

One Belt One Road: China-Greece Belt and Road Joint Laboratory on Cultural Heritage Conservation Technology

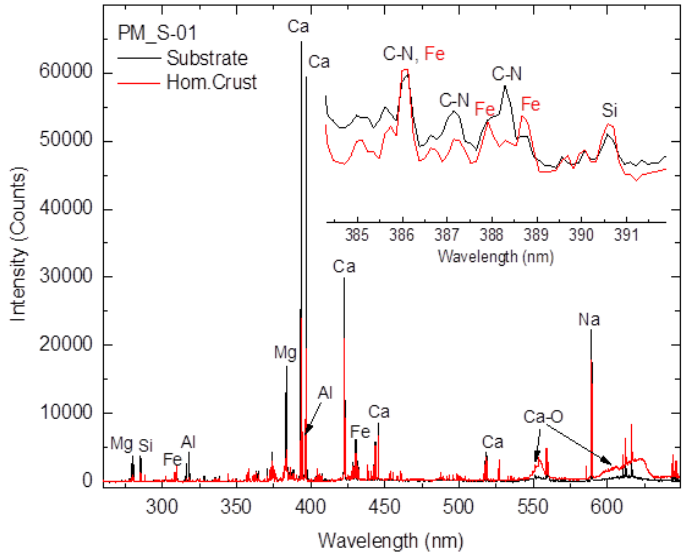
中国–希腊文物保护技术
"一带一路"联合实验室
CHINA-GREECE BELT AND ROAD JOINT LABORATORY ON CULTURAL HERITAGE CONSERVATION TECHNOLOGY

- Scientific Works towards the development of customized laser cleaning and analysis methodologies for
  - a) pollution crusts on stonework and
  - b) corrosion layers on metals





LIBS



Photonics for HERITAGE SCIENCE

FORTH INSTITUTE OF ELECTRONIC STRUCTURE AND LASER

April 29th, 2022 - 09:30 EEST / 14:30 CST

China - Greece dialogues on Heritage Research and Conservation

Costas Vasiliadis - The Acropolis Museum

The Erectheion Caryatids: Conservation Interventions and Removal of Pollution Encrustation by Means of Laser Technology

12th FORTH RETREAT 2022

FORTH INSTITUTE OF ELECTRONIC STRUCTURE AND LASER

中国-希腊文物保护技术"一带一路"联合实验室

China-Greece Belt and Road Joint Laboratory on Cultural Heritage Conservation Technology

China - Greece dialogues on Heritage Research and Conservation

FUTURE EVENTS

- 24/06/2022, **Kunfeg Wei** (Inst. of High Energy Physics, Chinese Academy of Sciences)
  The Applications and prospects of the X-ray Imaging Technology in Cultural Relics
- 28/07/2022, **Paraskevi Pouli** (FORTH),
  Laser cleaning; a tailored relation between materials and light
- 28/09/2022, **Eliza Kavoulaki** (Ephorate of antiquities of Heraklion),
  Palace of Knossos: The previous conservation and restoration works and the recent strategies within the HERACLES EU project
- 24/11/2022, **Andreas Karydas** (Institute of Nuclear and Particle Physics, NCSR "Demokritos"),
  Portable μ-XRF instrument; development and applications

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Lasers for Art's Sake

Photonics for HERITAGE SCIENCE

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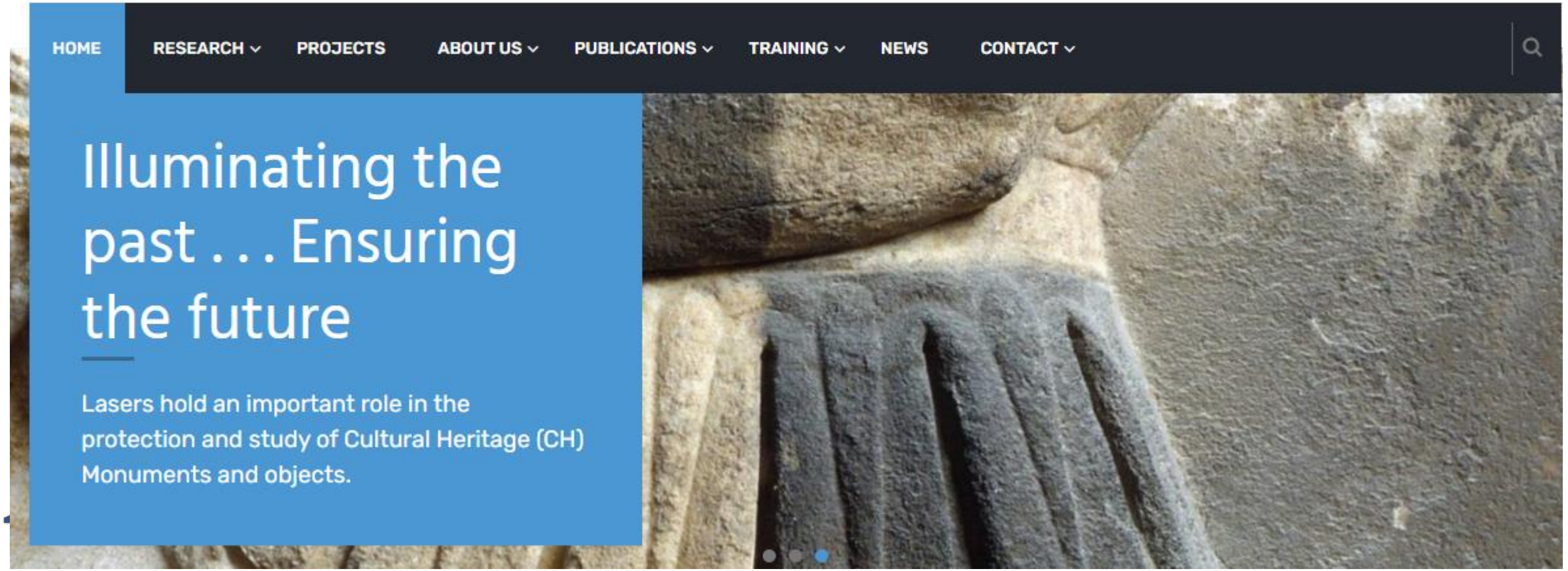

PhoHS team of IESL-FORTH


Laser Spectroscopy:

D. Anglos, S. Sotiropoulou, P. Siozos, A. Philippidis, A. Giakoumaki, V. Pinon, O. Kokkinaki





Spectral Imaging:

K. Hatzigiannakis

Holographic Interferometry:

V. Tornari, M. Andrianakis


Laser Cleaning:

P. Pouli, K. Melessanaki

Thank you for your attention!

E-RIHS
EUROPEAN RESEARCH INFRASTRUCTURE FOR HERITAGE SCIENCE

IPERION HS
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HELLAS-CH
The HiPER, ELI and LASERLAB Europe Synergy & IPERION-CH.GR

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NIKI: China-Greece Laser Technology Joint Laboratory on Cultural Heritage

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