



# LA TECNOLOGIA ALLA SCOPERTA DEI DISEGNI E DELLE PITTURE DI LEONARDO

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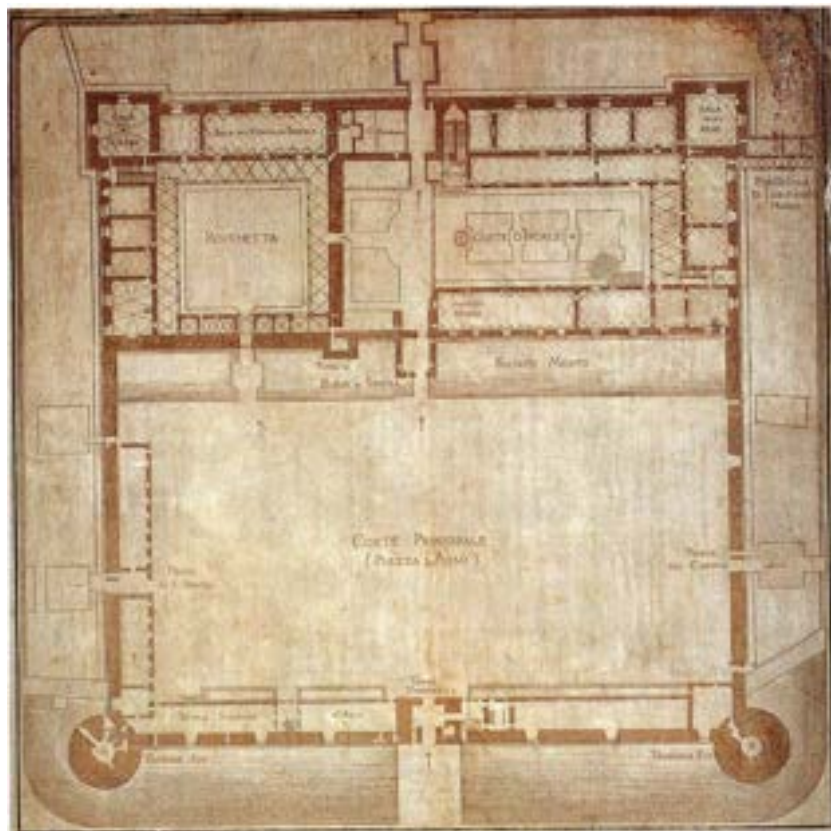
Photonics 4

Cultural Heritage

Castello Sforzesco Milano, Italy

1st December 2023

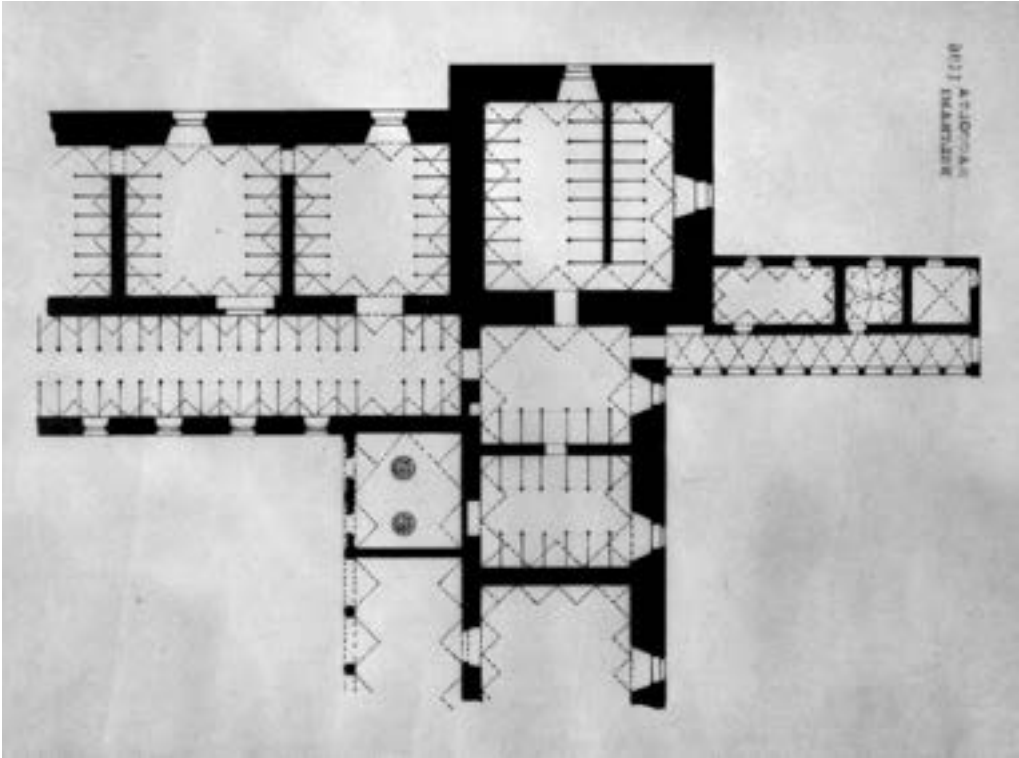




A la saletta negra nò si peudt tempo / Lunedì si desarmarà  
la Camera grande da le asse: cioè da la torre /  
mò Leonardo promette: finirla p tuto Settembre  
in che per questo si potrà etiam goldere: perché li ponti  
ch' el farà lasarano vacuo de soto p tuto /

**“A la saletta negra non si perde tempo. Lunedì si desarmarà la Camera grande da le asse, cioè da la torre. Magistro Leonardo promette finirla per tuto Settembre, et che per questo si potrà etiam goldere: perché li ponti ch’ el farà lasarano vacuo de soto per tuto”**

# Vicende conservative

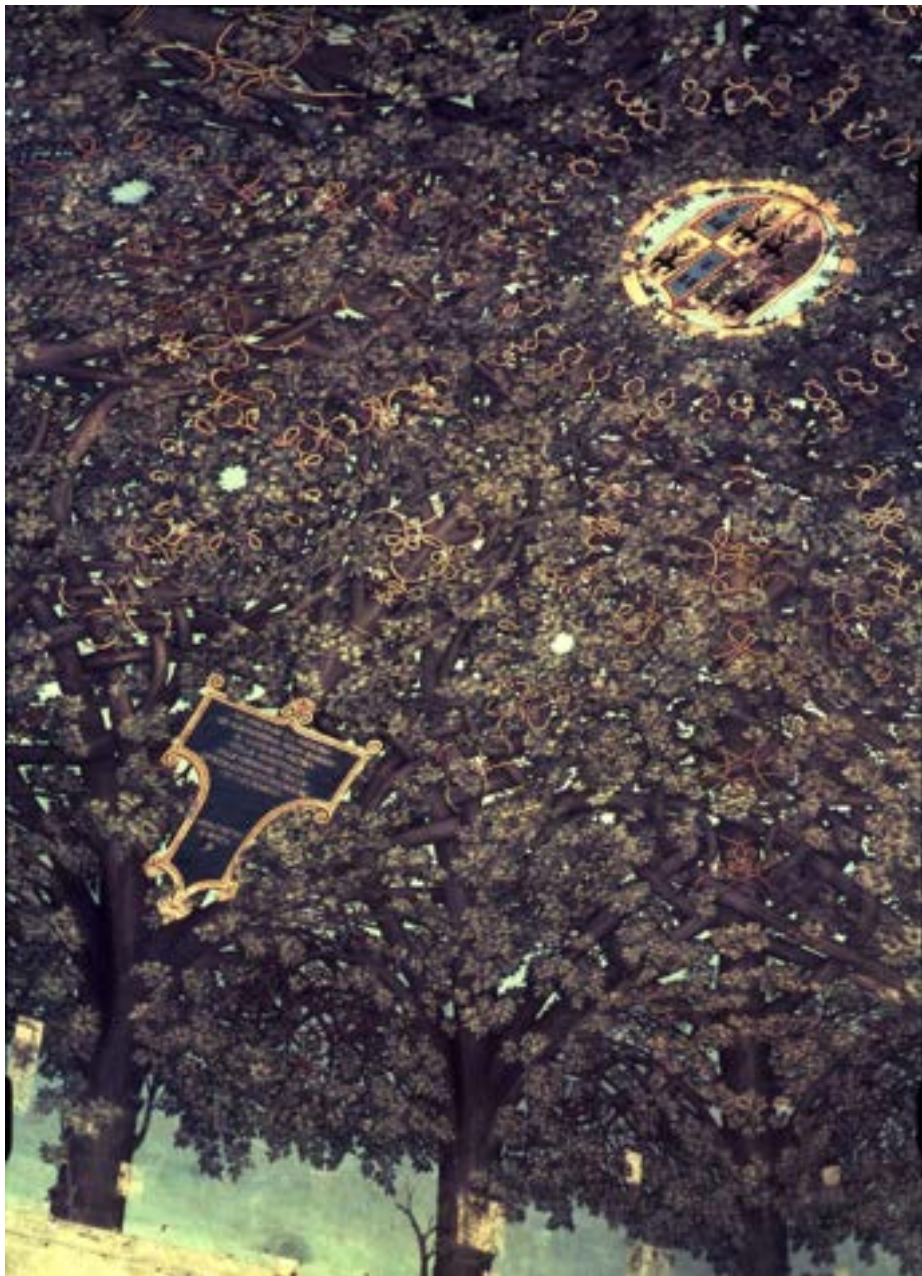




## Intervento di fine '800: Luca Beltrami ed Ernesto Rusca







Particolari della volta dopo l'intervento di ridipintura di Ernesto Rusca, Civico Archivio Fotografico, Milano, 1902-1908 ca.

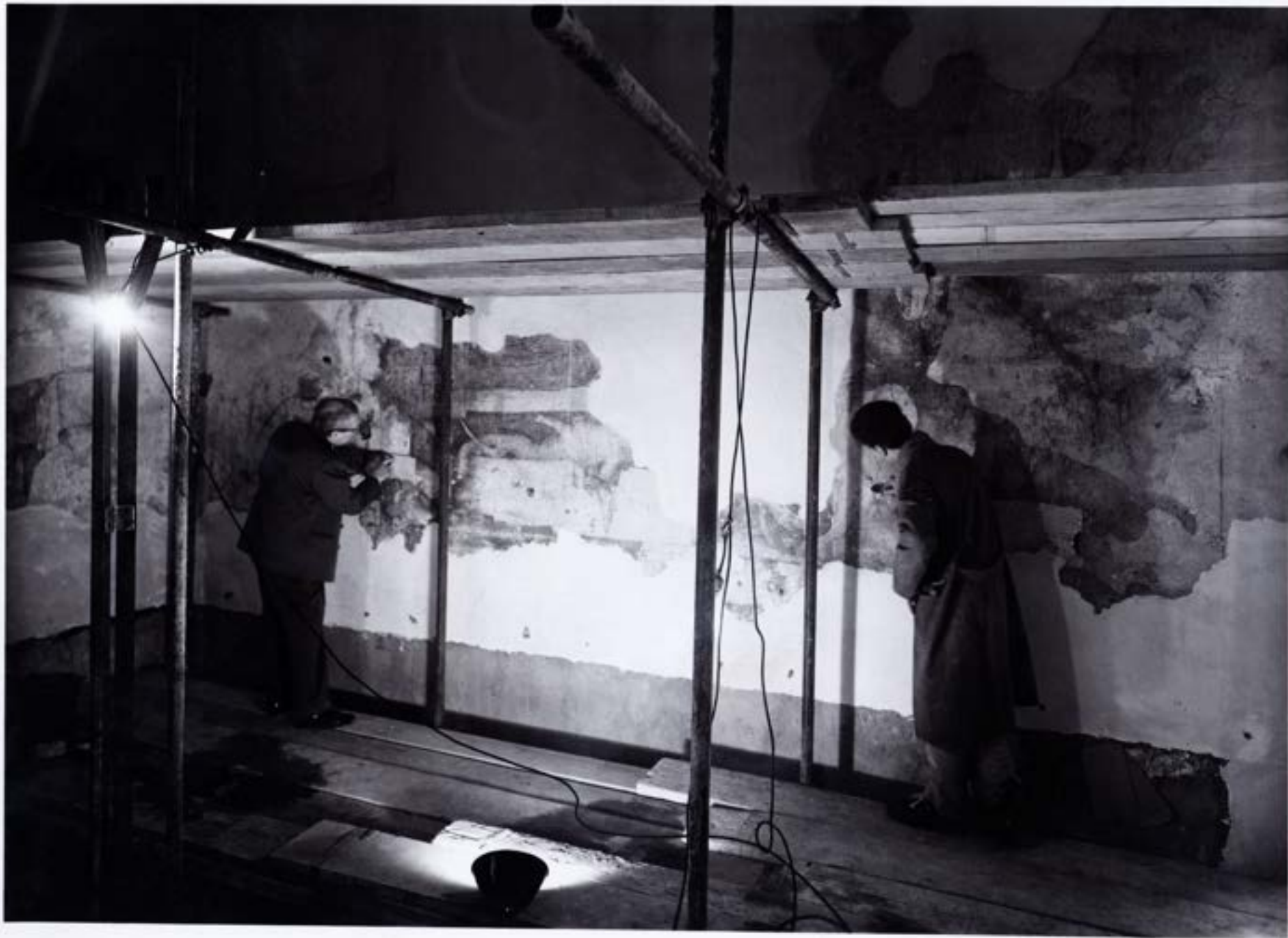
## Intervento di metà '900: Ottemi della Rotta e BBPR









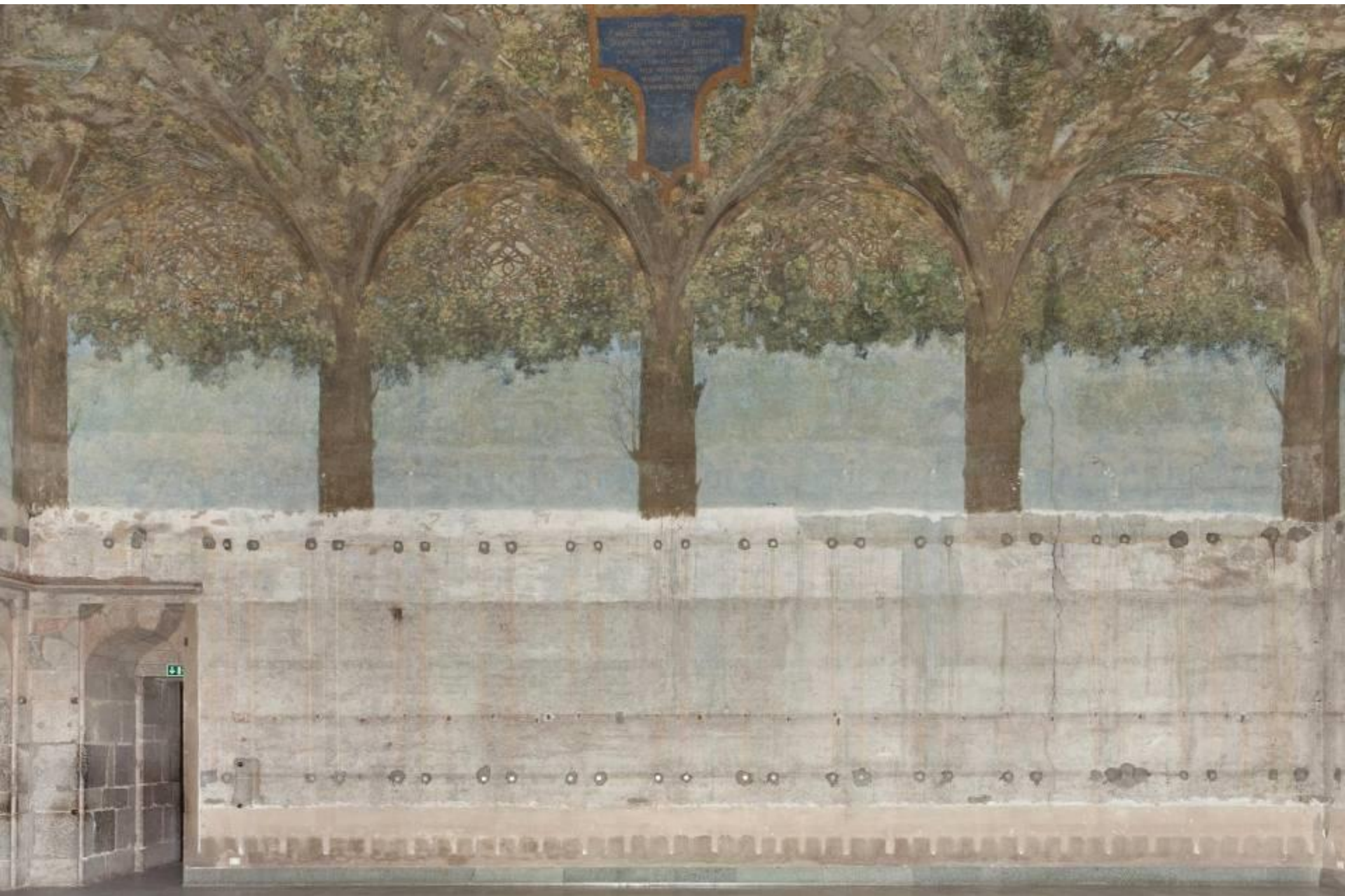






# Il restauro in corso







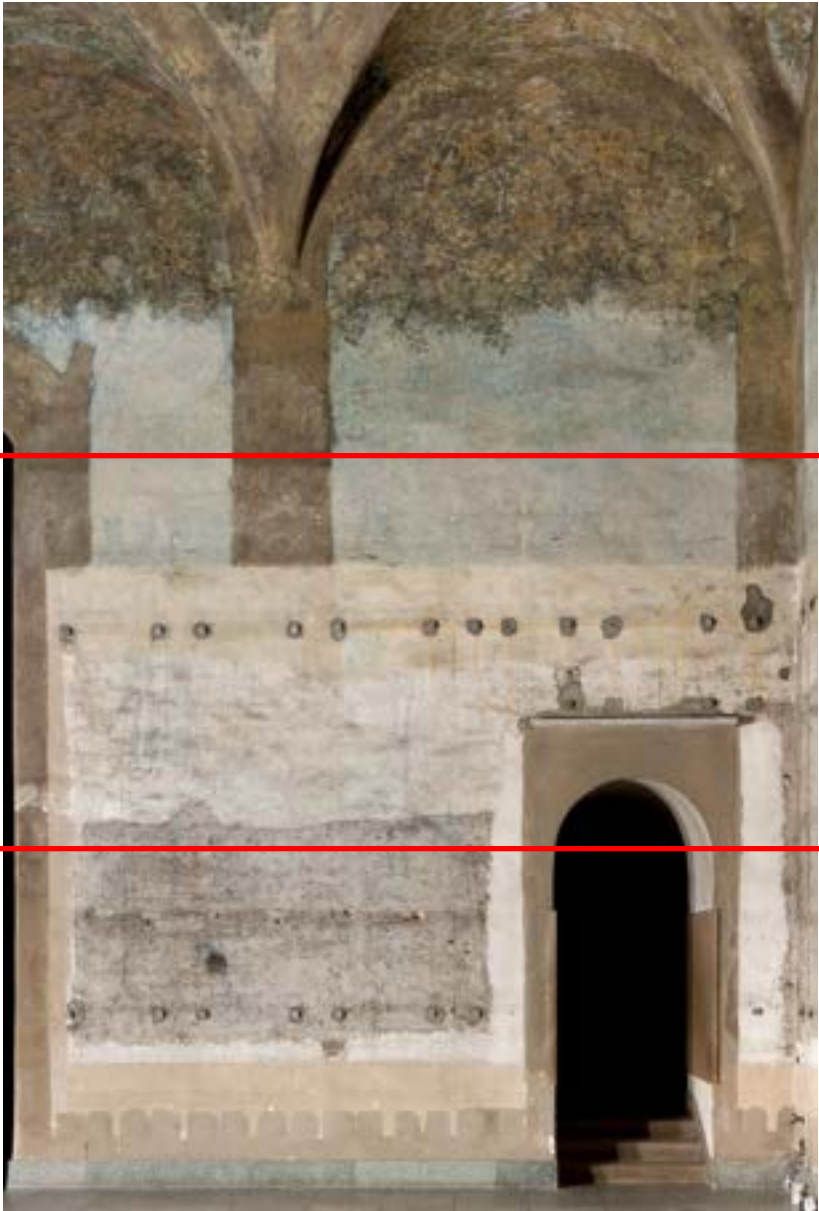
## Fase 1: il *Monocromo*





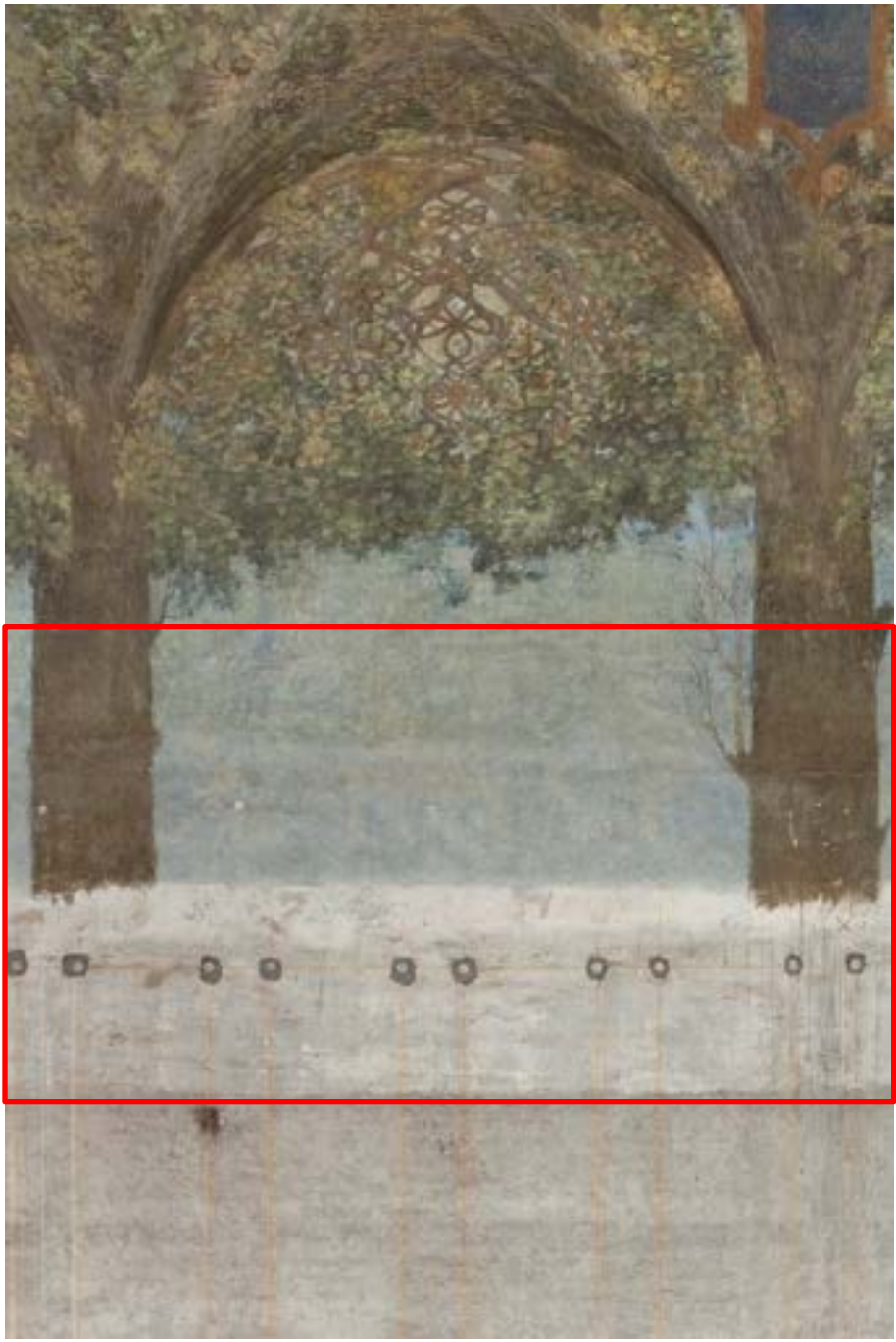


# Fase 2: le tracce di disegno preparatorio













## Fase 3: la policromia







# LASER CLEANING TIMELINE

1970s

✓ First cleaning trials by J. Asmus, L. Lazzarini – Venice

✗ Big technological limits!



1980s

✓ Technological improvement

✗ High costs

✗ skepticism

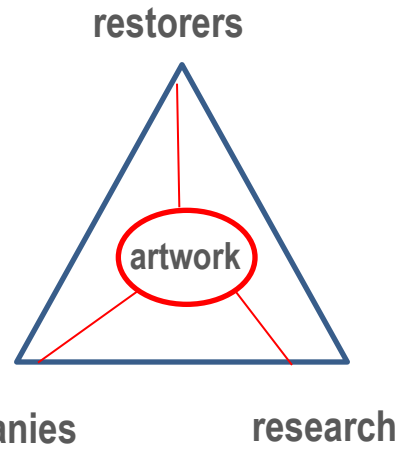


1990s

✓ Technological CLUSTER

✓ First LACONA 1995 – Crete

✓ Scientific validation of the process



# LASER CLEANING TIMELINE

2000s

- ✓ Optimisation of laser parameters
- ✓ Application to **metals and wall paintings**
- ✓ Overcoming of the yellowing problem
- ✗



Easel paintings?

2010s-  
today

- ✓ Study and validation of Er:YAG laser system
- ✓ Advent of fiber lasers

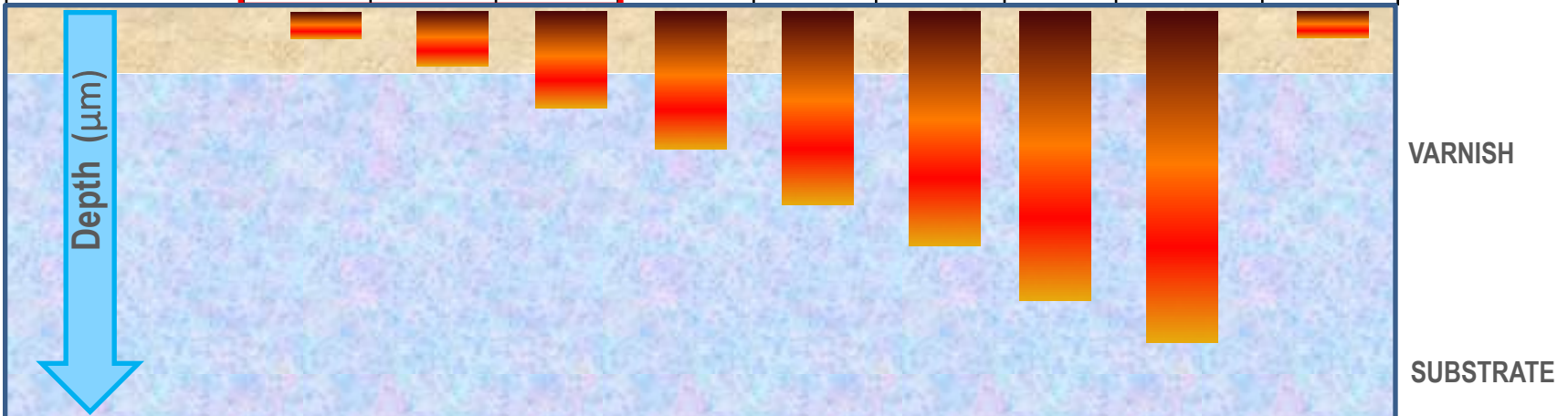




# THE IMPORTANCE OF WAVELENGTH

INCREASING WAVELENGTH

Laser	UV				Vis			IR	
Excimer	193	248	308	351					
Nd:YAG	213	266		355		532		1064	
Er:YAG									2940
Ti:Sapphire		265			398		795		



# THE IMPORTANCE OF PULSE DURATION



QS = Q-switch 10ns

**! PHOTOMECHANICAL et !**

Optimised pulse durations



LQS = Long Q-switch 100ns

**SPALLATION (detachment)**



SFR = Short Free Running 50-150  $\mu$ s

**VAPORIZATION**

5-15 ns

100 ns

20-130  $\mu$ s

500  $\mu$ s

regime

QS –  
Q-SWITCH

LQS  
Long Q-switch

SFR  
Short Free Running

FR  
Free Running

wavelength

1064 nm  
532 nm

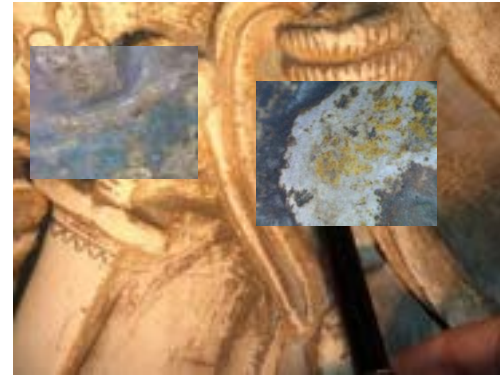
1064 nm

1064 nm

2940 nm



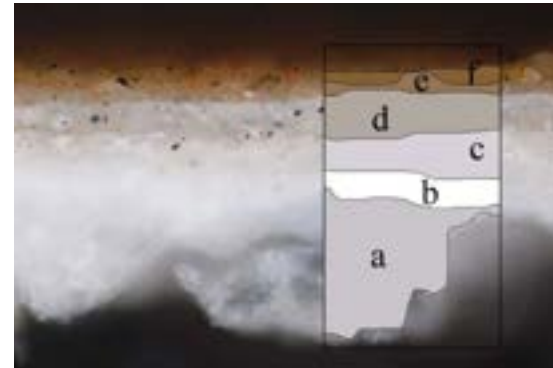
# LASER CLEANING: WHY AND WHERE?



# ROME – palazzo farnese , sala carracci



- Frescoes by Annibale Carracci and his school
- 1597 – 1607
- On the vault «The loves of the Gods», based on Ovidio's Metamorphosis
- Links in style with Renaissance masters
- Cartoni « a spolvero »
- Fresco with some a secco finishing touches



- A- Roman Stucco
- B – white scialbo
- C – white scialbo
- D – white with black grains
- E – Dark brown layer with red, yellow and brown grains
- F – Brown layer with black, red and yellow grains



# ROME – palazzo farnese , sala carracci



## Different lasers for different problems

- **LQS laser** useful for scialbo layers removal and to preserve the original stucco surface. This laser preserves the sanguine drawings too. On graphite drawings only very low fluences can be applied (0,5 J/cm<sup>2</sup>).
- **QS laser** with green light (532nm) has been more suitable on graphite , allowing more treatments (3-4 ablations) for refinishing the drawing cleaning.
- **Er:YAG laser** has been extremely useful for preserving chalk drawings and signs.



# ROME – palazzo farnese , sala carracci



- P.C. – K-G 37-38 – engraving drawing– Prob. Level 0 e 1
- Laser EOS COMBO
  - SFR ; E = 200-300-400 mJ ; f = 2-4 Hz; spot  $\varnothing$  = 3-3,5 mm
  - LQS 3 E = 450 mJ +/- filter 25%; f = 2-3-8 Hz; spot  $\varnothing$  = 2-3 mm
- Laser Er:YAG, Short: E = 300 mJ; f = 5 Hz; spot  $\varnothing$  = 4 mm



# ROME – palazzo farnese , sala carracci







# LASER APPLICATION FIRST PHASE 2017-2019

- Intervention on all four walls aimed at the identification of traces of Leonardesque decoration with laser technology
- The traces of drawings to be identified were concealed under «Scialbi» of different thicknesses with lime and tempera
- The drawings are made with charcoal, brush, drips, engravings, etc.
- Combined use of laser and scalpel
- Various lasers employed:
  - (1064nm) Nd:YAG QS
  - (1064nm) Nd:YAG LQS
  - (1064nm) Nd:YAG SFR
  - (2940nm) Er:YAG



# LASER APPLICATION FIRST PHASE 2017-2019



Wall 3 Lunette 1-2: different levels of thinning of the *scialbo* layers



Wall 3 Lunette 2: details during the *descialbo* treatment



# LASER APPLICATION FIRST PHASE 2017-2019



before



after

# LASER APPLICATION FIRST PHASE 2017-2019



Wall 3 Lunette 2-3: during the descialbo operation

# LASER APPLICATION FIRST PHASE 2017-2019



before



after



# LASER APPLICATION FIRST PHASE 2017-2019: RESULTS



Very long and delicate intervention



Prevalent use of Nd:YAG, differentiating its use depending on the thickness to be removed (LQS for thin scialbo, SFR for thick scialbo (250-300  $\mu\text{m}$ )).



Secondary spallation exploited (detachment and not ablation)



Cleaning almost always dry, integrated and alternated by the scalpel

# LASER APPLICATION FIRST PHASE 2017-2019: RESULTS

## TWO PHASES:



circumscription of the decoration traces with Nd:YAG system at LQS1 mode



finishing with synergies of instruments between LQS+SFR or SFR+LQS at low fluences or with Erbium laser +SFR/LQS



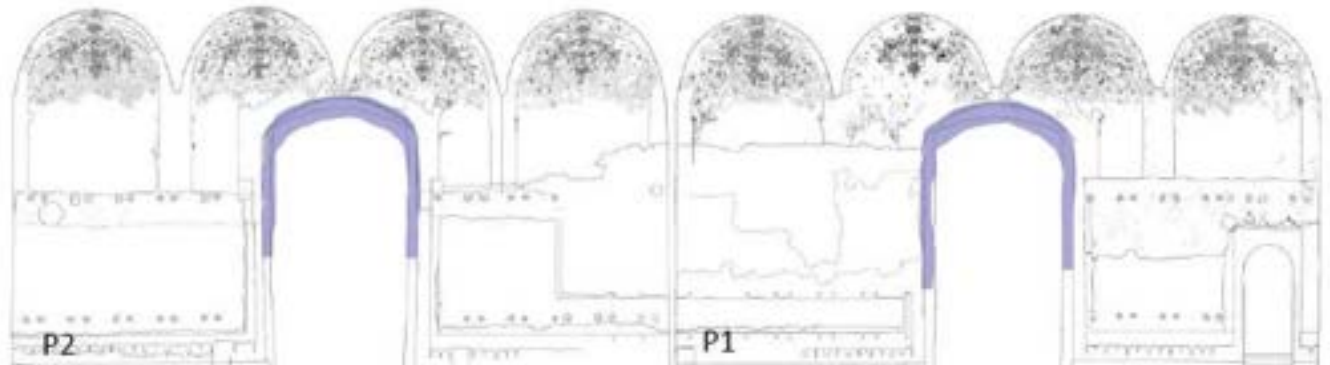
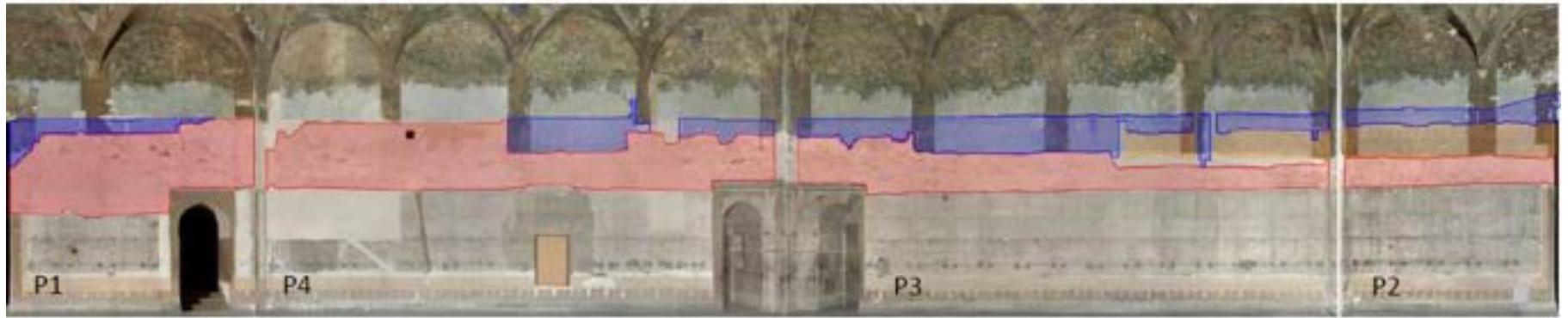
before

! Er:Yag laser used in particularly delicate points !



after

# LASER APPLICATION SECOND PHASE 2020-2021



In **red**, the areas with finishing of cleaning;  
in **blue** the new areas where scialbo is being removed  
in **orange**, the areas where twentieth-century repaintings were removed.



# LASER APPLICATION SECOND PHASE 2020-2021

! The intervention was very long and complicated by the presence of different materials.

Every centimeter, the ablative phenomena of the chosen laser devices changed the dynamics of radiation absorption depending on the optical and chemical properties of the material encountered on the surface or on the underlying layers.



# LASER AND POLYCHROMY



Laser also used for the removal of repaints.



removal of the brown band with laser technique.



# LASER AND POLYCHROMY

## THE BLUE SKY

- 1 treatment with a swab with acetone to roughly remove the dust deposits and depolymerize the intervention of the Ottemi della Rotta
- 2 Treatment with different synergies of Nd:YAG and Er:YAG lasers to remove the overpaint layer



When one or more layers of *scialbo* were found in the interface of the original polychromy, it was necessary to operate only with Nd:YAG laser (LQS) and with some scalpel finishing.

















# Leonardo da Vinci



**Thank you  
for your  
attention!**