UNIVERSITÀ DEGLI STUDI DI MILANO
DIPARTIMENTO DI FISICA

Giotto unveiled: new developments in imaging and elemental analysis techniques for Cultural Heritage

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The Context

Exhibition "Giotto e l'Italia" Palazzo Reale, Milano, 02/09/2015-10/01/2016

14 Giotto's masterpieces never shown together before.

The Project

AIM Investigating the organizational model of Giotto's workshop through scientific analyses of a never investigated work: the "Cusp" of San Diego.

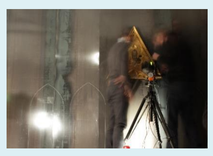
WAY non-invasive analyses, with portable instruments and with times compatible with opening hours of exhibition (4 diagnostic campaigns, 6 hours of work/campaign, no interruption of exhibition).

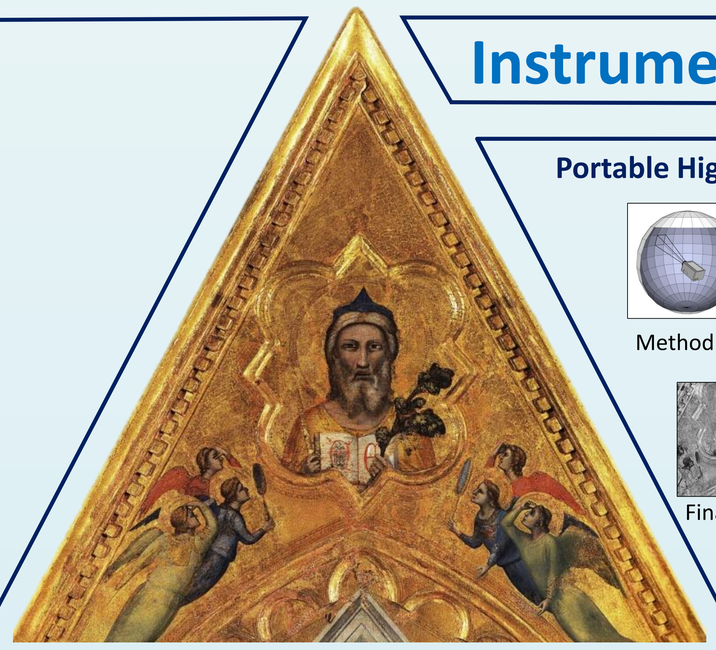
The *in situ* campaign

Imaging techniques
- Vis image
- IR Reflectography (SW &LW)
- IR False Color

Pigments analyses
- Reflectance Spectrometry
- ED-XRF

Post-processing
- Study of the underdrawing
- Material's mapping

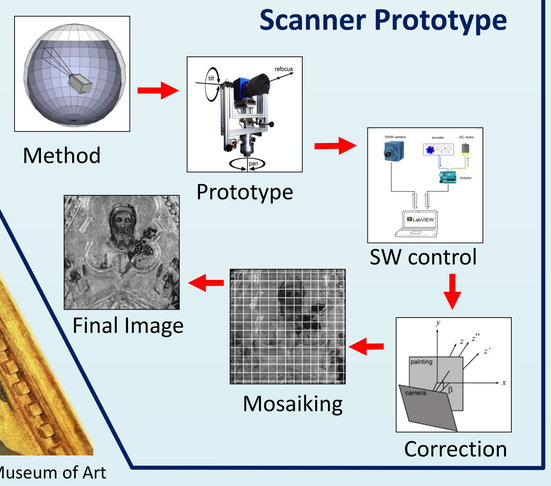



God the Father with Angels, ca. 1330, tempera and gold on panel, San Diego Museum of Art

Instrumentations

Portable High Resolution InGaAs Spherical Scanner Prototype



Pigment Characterization

25 points analized through:

FORS (Fiber Optical Reflectance Spectroscopy)

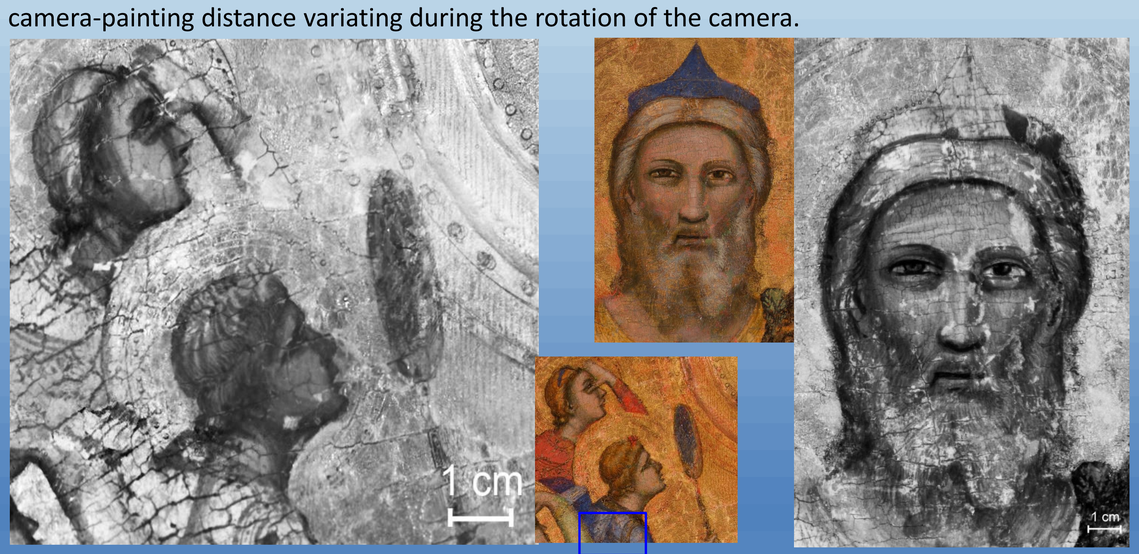
Ocean Optics HR4000 (380-1050 nm, 2.7 nm spectral res.)

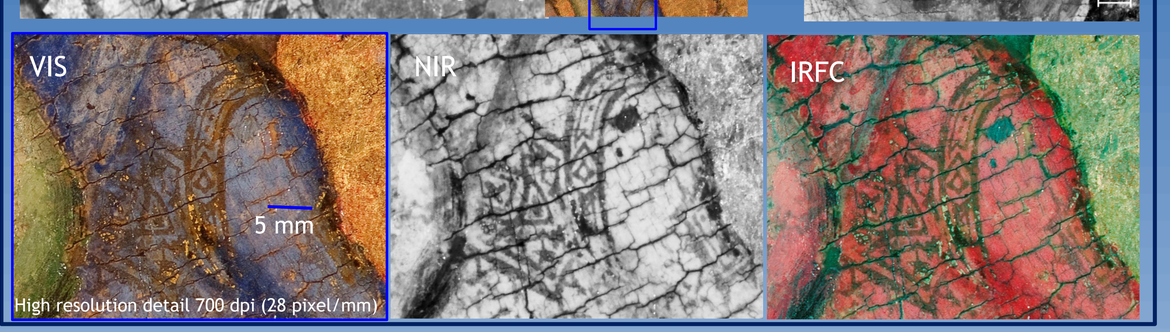
ED-XRF (Energy Dispersive X-ray Fluorescence)

ELIO Spectrometer XGlab srl (Rh anode, 50kV, 80μA, 120sec)

Results: HR Infrared Reflectography

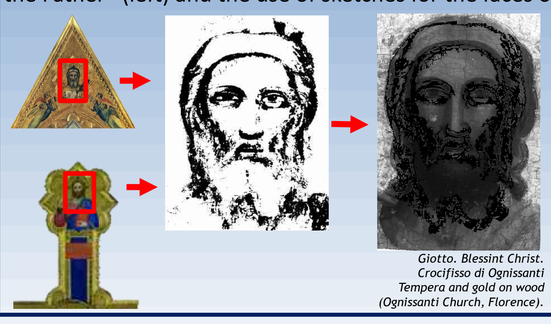
The campaign gave the opportunity to test a portable spherical scanning system prototype exploitingan InGaAs camera. The motorized head was built in the mechanical officina of Our department with the purpose of allowing the refocusing adjustment needed to compensate the camera-painting distance variating during the rotation of the camera.





Study of the underdrawing: Use of Patrones?

The imaging data support the hypothesis of a detailed underlying drawing, including bigger brush signs. Applying image segmentation and pattern recognition algorithms to the IR images, the use of patrones for the face of "God the Father" (left) and the use of sketches for the faces of angels (right) might be thought.



Giotto. Blessint Christ. Crocifisso di Ognissanti Tempera and gold on wood (Ognissanti Church, Florence).

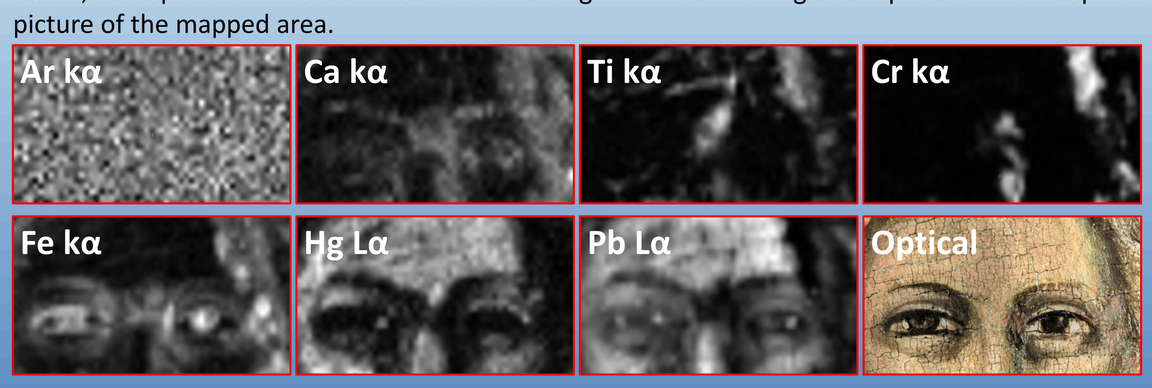
The underdrawing

After image segmentation: preparatory drawing

Rigid coregistration of the edges of the angels
Min rotation: 0.9°
Max rot.n: 5.8°

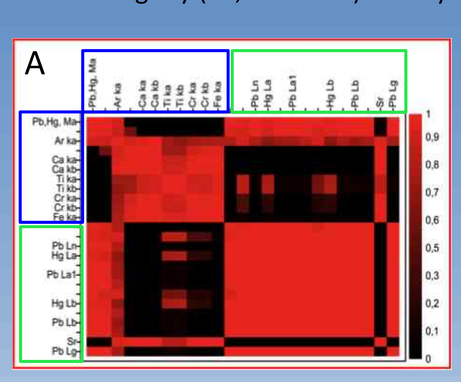
Results: p-XRFelemental mapping

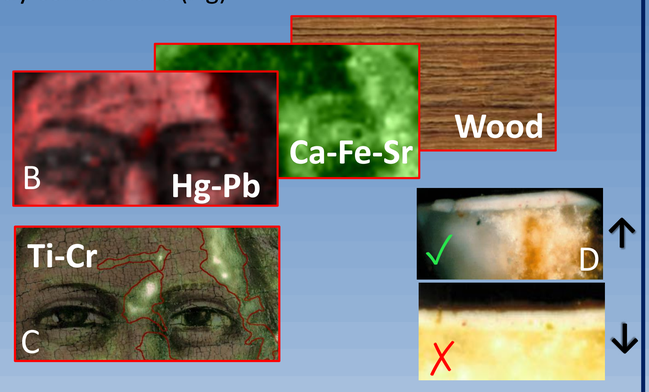
An algorithm that automatically identifies the transition bands from the distribution of the peaks location was realized; it also organizes the spectra as a 3D matrix and integrating into energy it computes the band images.
Below, we report a choice of some of the most significant band images compared with the optical picture of the mapped area.



Band images are arranged as vectors and the normalized cross-correlation functions is computed. The resulting matrix (Panel A) summarizes the degree of similarity of the elemental maps each other and shows that:

- two groups of band images are closely cross-correlated (Hg-Pb and Ca-Fe-Cr-Sr) but anti-correlated each other
- Ti has slightly (Ca, Sr and Cr) or very slightly correlations (Hg)





Some conclusions can be drawn on these bases: (i) the M_α X-ray lines of Hg and Pb are detectable, so they pertain to the superficial layer, (ii) Cr and Ti (typical of modern pigments) co-localize and indicate the restoration regions (Panel C). (i) suggests that the mapped area is the result of the superposition of two different layers (Panel B). This technique was already adopted by Giotto (Panel D, ↑ cross-section, Santa Maria Novella Cross, 1290 ca.) as alternative to the Hg-Pb-Fe monolayer (Panel D, ↓ cross-section, Ognissanti Cross, 1315 ca.) .

Acknowledgments The authors are very indebted to XGab for placing ELIO spectrometer at disposal. The authors would like to especially thank Michael A. Brown, Associate Curator of European Art at the San Diego Museum of Art.