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# INFN-CHNet meets CCR La Venaria Reale: first results

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***Abstract* – In the field of Heritage Science, mobile instruments for diagnostic of artworks are more and more in use. INFN-CHNet, the network of INFN devoted to Cultural Heritage, develops instruments and methods to support the research in the field. Among the others, a MA-XRF scanner was built for in-situ analysis, and is now fully operative. The INFN-CHNet MA-XRF scanner was employed at the CCR "La Venaria Reale", Turin, for the analysis of different artworks under conservation. The versatility of the MA-XRF scanner is highlighted by the diversity among the applications (painting on canvas, panel painting, and wooden cabinet).**

## I. INTRODUCTION

Presently the use of non-destructive non-invasive X-Ray based techniques is well established in Heritage Science for the analysis and the conservation of artworks [1-7]. X-Ray fluorescence (XRF) technique plays a fundamental role since it provides information on the elemental composition, and thus contributes to identify the materials present on the superficial layers of an artwork.

Whenever XRF is combined with the capability of scanning an area, providing an elemental distribution on a surface, the technique is indicated as Macro X-Ray Fluorescence (MA-XRF).

A number of MA-XRF scanners, commercial [8] as well as built in-house [9], are nowadays available and in use for Cultural Heritage applications. Due to the impossibility, for their preciousness or high weight, to transport some artworks inside a laboratory for the analysis needed, an important class of instruments is made up by portable and transportable scanners.

In the present paper we are going to present the Cultural Heritage Network of the National Institute of Nuclear Physics (INFN-CHNet) MA-XRF scanner, developed in-house within the collaboration, through the analyses carried out at the Centro Conservazione e Restauro (CCR) "La Venaria Reale", located nearby Turin. Different examples of artworks are presented, and elemental maps are shown to illustrate the capabilities of the instrument.

## II. EXPERIMENTAL SET-UP

The INFN-CHNet MA-XRF scanner, shown in Fig. 1 during its installation at the CCR "La Venaria Reale", is a compact (60×50×50 $cm^3$) and lightweight (around 10 kg) instrument. Its main parts are a measuring head, three motor linear stages and a case containing all the electronics for acquisition and control.

*Fig.1 INFN-CHNet MA-XRF scanner positioned in front of a panel on canvas at the CCR La Venaria Reale.*

The measuring head is composed by a X-Ray tube (Moxtek©, 40 kV maximum voltage, 0.1 mA maximum anode current, Mo anode) with a collimator (typically 800 μm of diameter), a Silicon Drift Detector (Amptek© XR100 SDD, 50 $mm^2$ effective active surface) and a telemeter (Keyence IA-100). The motor stage (Physik Instrumente©, travel ranges 30 cm in x, 15 cm in y and 5 cm in z directions) holding the measuring head is screwed on the carbon-fibre case. Typical operating voltage is 30 kV. Signals are collected with a digitizer (model CAEN DT5780) and the whole system is controlled by a laptop.

The control-acquisition-analysis software is developed within the collaboration and allows both an on-line and an off-line analysis. For the MA-XRF analysis the output is a file containing the scanning coordinates and for each position the spectrum acquired. For each map, a single element can be selected and shown in the scanned area, or in a part of it. The relative intensity of each element in a map is shown with a grey scale, in which the maximum intensity is in white and the lower is in black. Scan is carried out on the x axis, and a step size of typically 1 mm is set on the y axis resulting in a pixel size of 1 $mm^2$. A complete review on the instrument can be found in [10].

## III. CASE STUDIES

In this paragraph different applications are presented. The first is a painting on canvas, the second is a painting on panel, and the last is a wooden cabinet. One single problematic for each artwork is reported.

### *A. Partial loss of the painting layer*

"Madonna con Bambino e i Santi Crescentino e Donnino" by Timoteo Viti, early XVI c., is reported as an example of tempera on canvas. This painting was analysed since its condition required to find out the traces of the original pigments, in order to assess its conservation state. A picture of the painting is presented in Fig.2.

*Fig.2 Madonna con Bambino e i Santi Crescentino e Donnino by Timoteo Viti. On the bottom right, a magnification of the Virgin's face.*

To retrieve the original pigments used in the area of the Virgin's face, the elemental maps of Fe, Hg, Cu, and Au have been extracted and are reported. The scanned area is 170×110 $mm^2$, acquisition parameters were 40 μA beam current and 3 mm/s speed.

The MA-XRF analysis led to the hypothesis of the use of earths-ochres in the shading, due to the presence of Fe, and vermilion-cinnabar (Fig. 3, Hg) in the fleshtones as well as the use of azurite (Fig. 3, Cu) for the Virgin's robe, decorated with gold like the halo (Fig. 3, Au) [11].

For this artwork, the MA-XRF analysis has permitted the detection of the traces of remaining painting layers and the study of the painting technique.

After the conservation carried out at the CCR "La Venaria Reale", the painting owned by La Pinacoteca di Brera was displayed at the exhibition *Raffaello e gli amici di Urbino*.

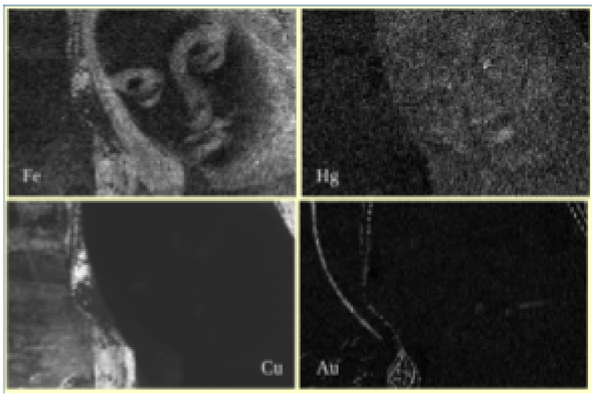


*Fig.3 Elemental maps of Fe, Hg, Cu, Au of the area of the Virgin's face.*

*B. Characterisation of the blue pigments*

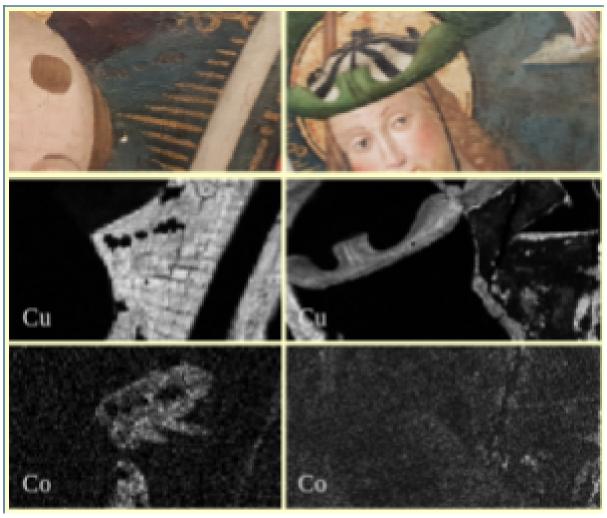


*Fig.4 Two areas of the Madonna con Bambino by Francesco Sparapane, oil on panel, XVI c. The corresponding maps of Cu and Co are presented. The scanned areas are, respectively, 12 7 cm$^2$ and 28 7 cm$^2$ .*

Blue pigments may be realized with different compounds (such as ultramarine, azurite, smalt, indigo). To identify the pigments used in the blue areas of "Madonna con Bambino e S. Antonio e S. Rocco" by Sparapane, partially visible in Fig.1, the MA-XRF analysis was carried out and two areas are presented in Fig.4.

The presence of Cu is likely due to the use of azurite, whereas the presence of Co, with traces of Bi and K, likely attests the presence of smalt [11]. In the first area (left), the elemental maps should indicate the presence of a large area of azurite with the presence of smalt in a smaller area (the maps of Bi and K are not reported), that could be explained with a later retouch or an original glaze. On the contrary, the map of Cu in the second area shows only a well-defined region outlining the face, due to a partial loss of the painting layer. The same conclusion is confirmed from the map of Co.

*C. Study of a Chinese wooden cabinet*

Together with paintings, the MA-XRF scanner was used on a wooden cabinet from the Castello di Masino, Piedmont, Italy, shown in Fig.5.

For this case study, the query was related to the presence of orpiment ($As_2S_3$) in the yellow areas. The maps of the area with flowers and stems is reported in Fig.6. The beam current was set to 30 μA and the speed to 3 mm/s.

*Fig.5 Chinese wooden cabinet. On the bottom right, a magnification of the area studied.*

Due to the overlap of their energies, the detection of As and S can not be stated directly with one map. By comparing the maps of different lines of As, Hg and Pb (not all reported), it was possible to attest the likely presence of orpiment in the stems. Further, the map of Au is reported in Fig.6, showing the gilding in the yellow flowers and leafs.

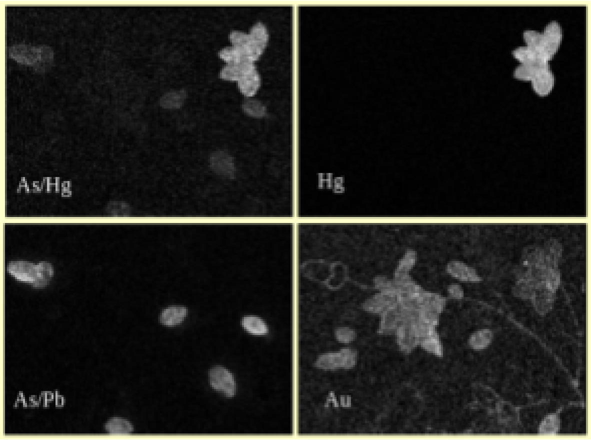


*Fig.6 Elemental maps at 11.7 keV (As/Hg), 9.9 keV (Hg), 10.5 keV (As/Pb) 9.6 keV (Au). The scanned is 14,5  10,5 cm$^2$ .*

## IV. CONCLUSIONS

The INFN-CHNet MA-XRF scanner was employed at the CCR "La Venaria Reale" to support the conservation activity. Its analytical performances and its versatility have demonstrated the usefulness of the instrument in the Cultural Heritage field. Further, thanks to the expertise within the collaboration, an upgrade of the scanner for adapting it to more and more application is continuously on-going.

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