

The Laboratório de Análise de Materiais por Feixes Iônicos-LAMFI of the Institute of Physics of the University of São Paulo has been installed an external beam facility for PIXE analysis. This new setup is being used for the analysis of archeological pottery artifacts, paintings and biological tissues (teeth and bones), which are not compatible with the high vacuum of the regular PIXE target chamber. Applications of this facility will be presented in the analysis of a Brazilian painting of the beginning of the last century.

The Accelerator LAMFI

General View of the LAMFI with the Pelletron tandem Accelerator, $V_{max} = 1.7$ MV



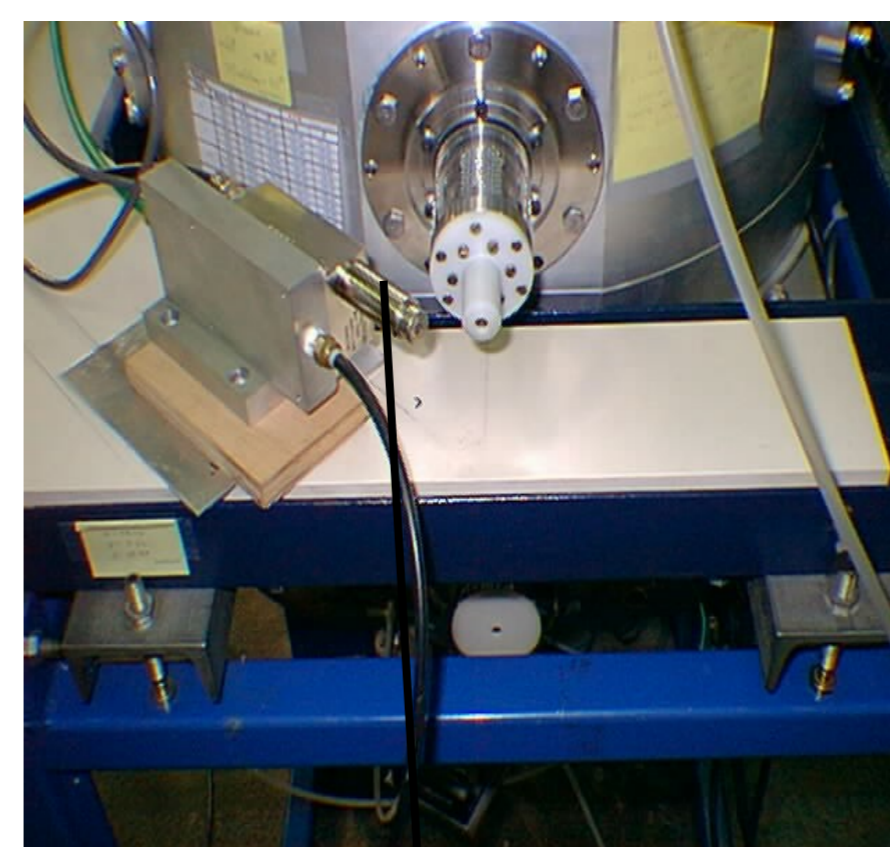
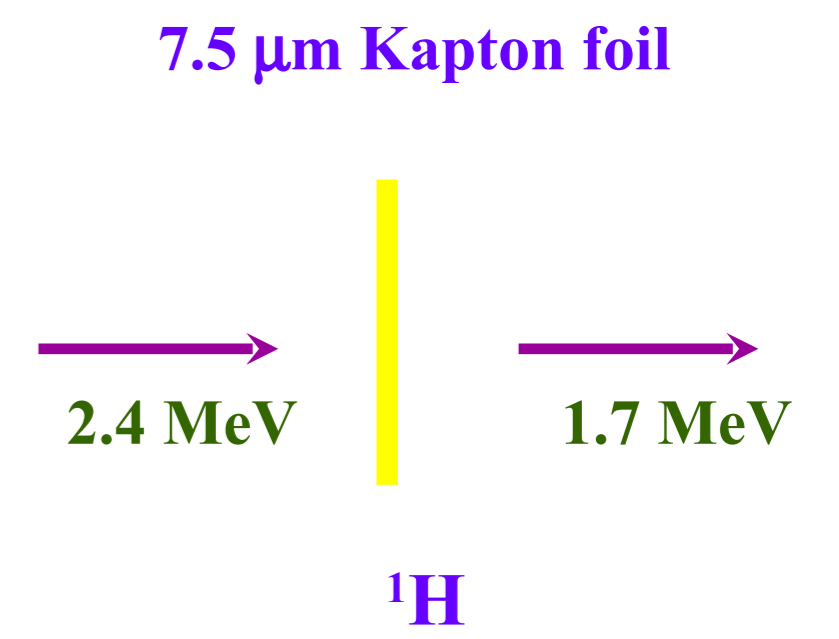
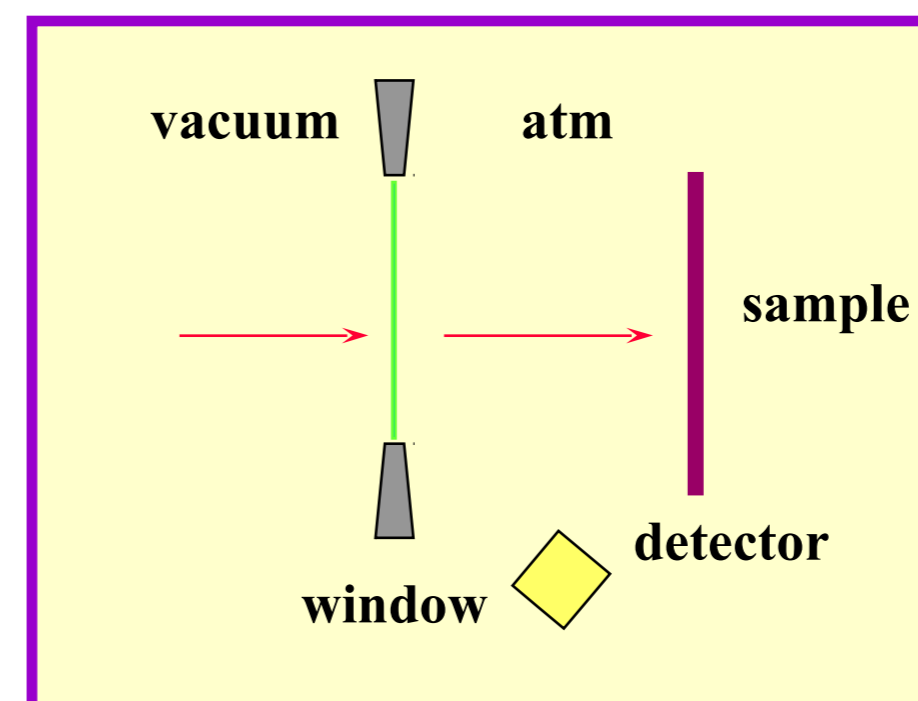
This new experimental setup optimizes the beam path through a carbon collimating ring placed inside a transparent perspex tube. To prevent electrical breakdowns the internal wall of the perspex tube was covered with a metal net, which avoids interference of electrical noise in the X-ray spectra.

In the measurements a 2.4 MeV proton beam, after passing through a 7.5 μm thick Kapton exit foil and 10 mm air path, reached samples with a final energy of 2.2 MeV. For X-ray detection a portable AMPTEC XR-100CR (Si-PIN) mounted on a water-cooled (FWHM 220eV@MnK α) kindly provided by Dra. Carmem C. Bueno, from IPEN-SP was used. This detector was placed about 10-15 mm from the target at an angle of 135 degrees related to the incident beam. To avoid the entrance beam into the detector a mylar absorber of 12 μm was placed in front of the detector.

Application

The analyzed painting was produced by a Brazilian painter in the beginning of the last century and consists of a picture of a landscape. The painting has 460 mm length e 185 mm width on a wood support. Typical beam currents used to analyze the painting were about some nA to keep dead time and pile-up low and to prevent painting damage. The acquisition time was set to 1 200 seconds for each point analyzed. The presence of air argon X-rays worsen somehow the detection limits for the K-lines of Cl and K. However the X-ray peak from Ar can be satisfactorily used for normalization. The intensity of the extracted beam was obtained indirectly using an Al foil inside the chamber and a Si particle detector. During the analysis part of the beam is Rutherford back scattered in the Al foil and measured in the Si detector. The Al peak spectra are normalized to known charge values. The painting was horizontally laid over at a distance of approximately 10 mm from the exit window. An Al collimator of 0.3 mm diameter limited the analyzed area and was positioned just after the external Kapton foil. The beam spot at painting is approximately 1 mm of diameter.

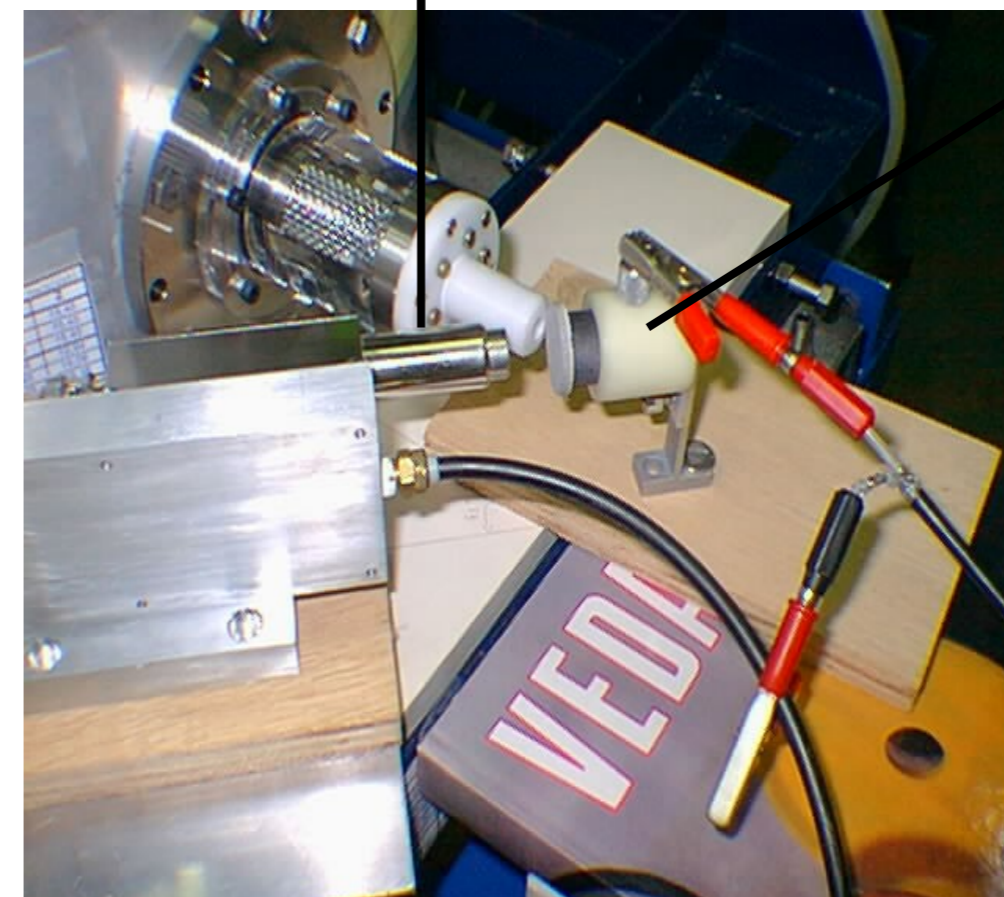
External Beam



X-Ray detector (XR-100CR).

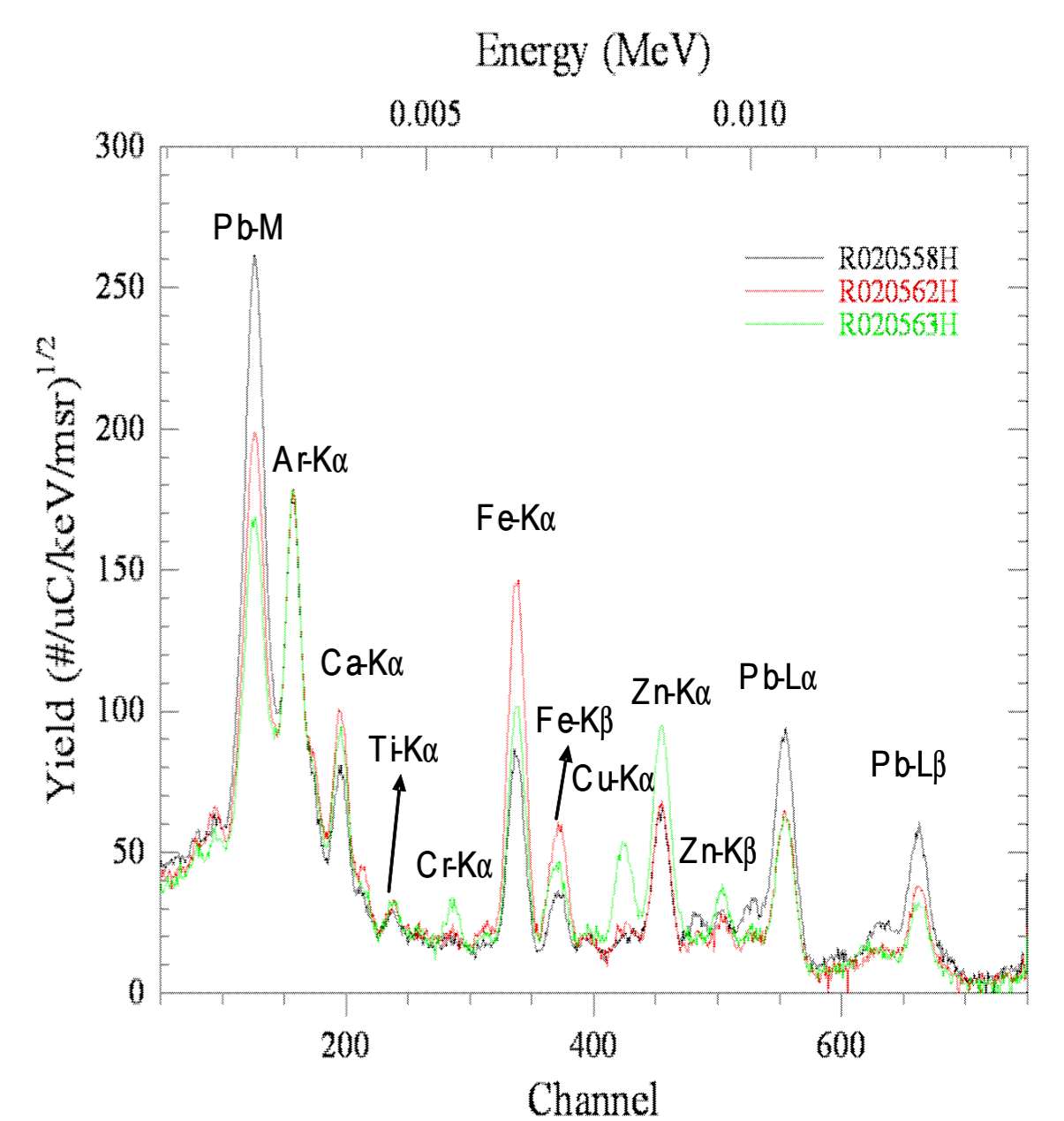


Carbon Faraday cup

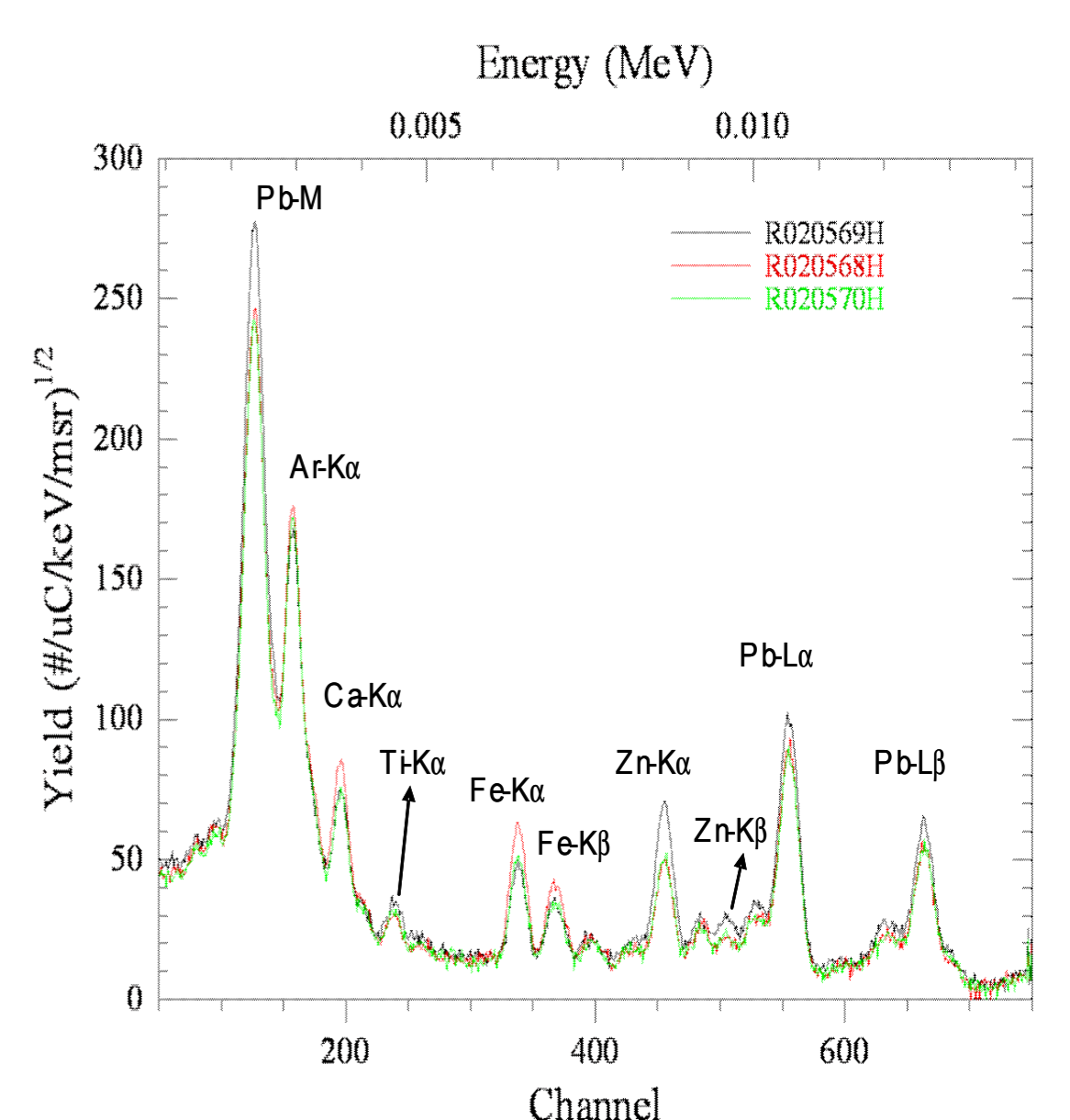


Some views of the external beam setup

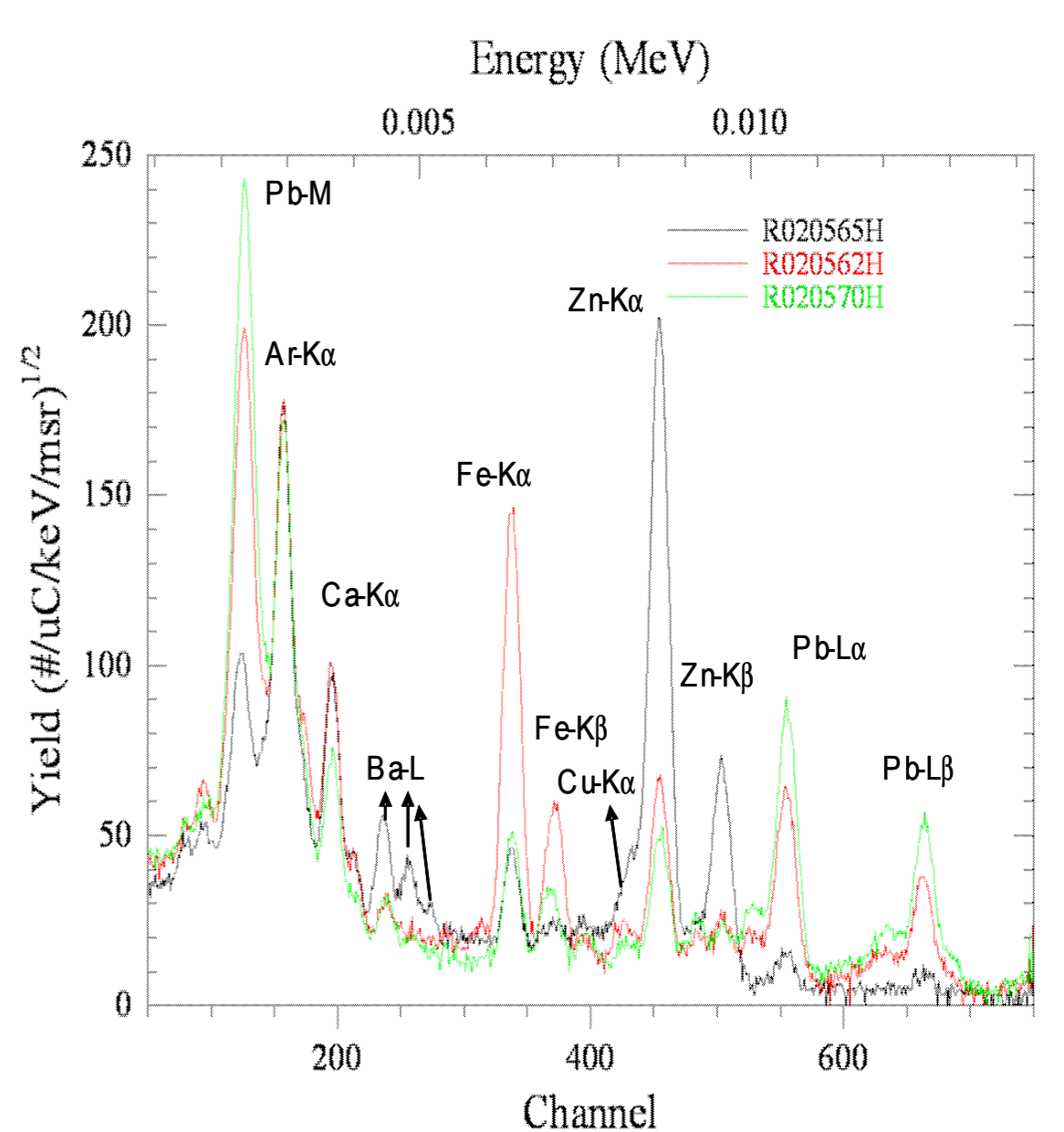
The PIXE spectra from brown group is shown corresponds to select point 3(dark brown) curve in black, 5(light brown) in green and 7(intermediated brown) in red. The greater difference is the presence of chromium and copper in the light brown. However there are intensities differences in lead, iron and zinc. The high intensity of Pb in point 3 (light brown) is in relation to the mixture of white color.



All points of the blue group (10 curve in green, 11 in red and 12 in black) in spectra PIXE show similar intensities for Ti. At point 11 – dark blue the intensities of Zn and Pb are little more than in points 10 – mountain blue and 12 – light blue. The intensities of calcium and iron at point 12 are slightly greater than in other points.



PIXE spectra show from points 2 – damaged white (curve in black), 7 – intermediate brown (in red) and 10 – mountain blue (in green). The greatest intensities differences appear in the damaged white point. At it there are almost no Pb and more zinc and copper than at the other points. PIXE spectrum from damaged white is the only showing barium K-lines, probably from priming. The point of intermediate brown presents more iron than that of mountain blue and damaged white.



Conclusion

PIXE can be used to analyze the elemental composition of a painting. The measurements were done non-destructively and no visible damage was observed on the irradiated painting. Qualitative analysis shows differences of elemental composition of the paint pigments which could allow to link paintings from the same painter. Improvements are needed for better analysis, although quantitative results are difficult to obtain.

