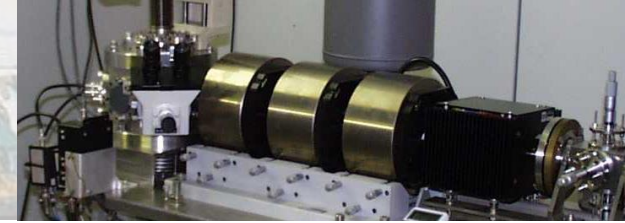# Application of Ion Beam Analysis Techniques to the Study of Cultural Heritage Objects

What is IBA?

- The IBA (Ion Beam Analysis) techniques use a high energetic beam of accelerated particles to study the composition/quality of different samples in a non-destructive way.
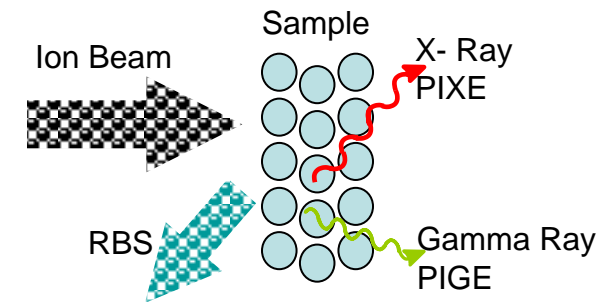
What is IBA?

- The accelerated beam induce in the sample the emission of secondary radiation or particles.

  There is a specific IBA technique to study each one:

  - PIGE (*Proton-Induced Gamma Emission*)

  - NRA (*Nuclear Reaction Analysis*)

  - ERDA (*Elastic Recoil Detection Analysis*)

  - RBS (*Rutherford Backscattering Spectrometry*)

  - PIXE (*Particle Induced X-ray Emission*)

What is IBA?

RBS and specially PIXE, with the possibility of using an external beam, are ideally suitable for Cultural Heritage studies.

Principal characteristics:

- Non-destructive - low beam currents are used.
- Possibility of puntual or scan analysis.
- Short time needed for analysis.
- The external beam is ideal for:
  - big samples,
  - fine samples (no vacuum is needed)
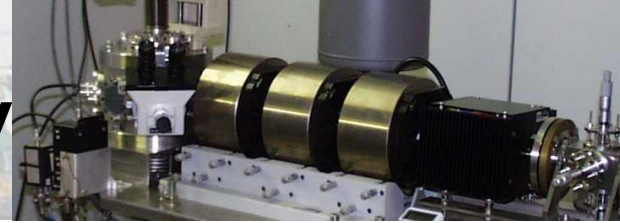 - not picking up samples

PIXE, What for?
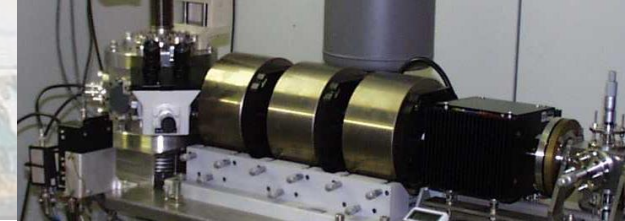
Fabrics

Paintings

Jewelry

Glasses

Coins

Sculptures

Ceramics

Inks/papers

and more...

Conservators, Restorers, Historians, Archaeologists,...

- Degradation degree
- Original materials used or after restaurations
- Surface treatments
- Etc.

PIXE for Coins/Jewellery

- Composition (gold, silver, copper, alloys…)
- Corrosion state
- Surface composition according with the surrounding environment where they were found
- Classification of the objects according the date/composition:
  - provenance (mines, workshops) identification,
  - counterfeits selection,
  - historical studies (manufacturing technologies, commercial, etc)

PIXE for Glasses, Stained Glass, etc

- Glass and pigments composition (Na, K, Fe, Cu, Pb…)
- Surface composition according with the surrounding environment (i.e. Humidity)
- Classification of the objects according the date/composition:
  - counterfeits selection,
  - historical studies

PIXE for Fabrics, Tapestries...

- Identify and evaluate the nature and the conservation state of the fibres and employed mordants by the Arraiolos dyers,
- Information on the composition, structure and degradation processes,
- Fibres evaluation of the fibre,
- Surface, fracture morphology and mordant analysis

PIXE for Sculptures, Ceramics

- Pigments composition,
- Surface composition according with the manufacture techniques
- Classification of the objects according the date/composition:
  - restoration,
  - Conservation processes

PIXE for Paintings
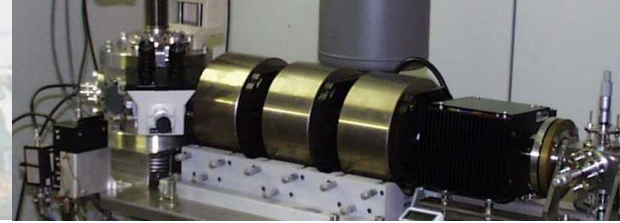
- Surface composition for a better and adequate rehabilitation/restoration:
  - organic / inorganic materials
  - varnish composition / thickness
- Actual pigments composition
- Homogeneity
- Study the deterioration according with the pigments
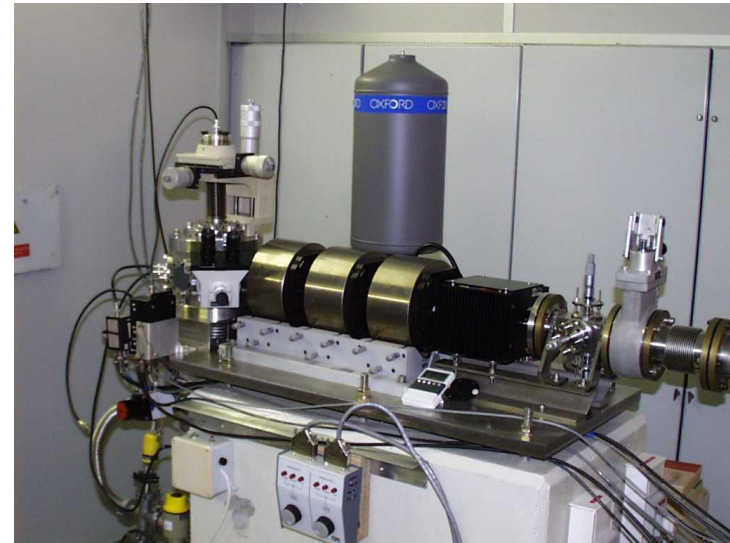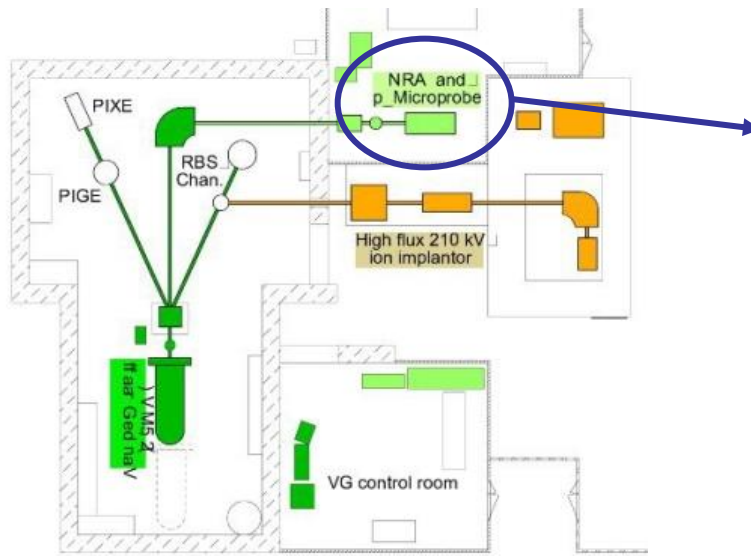
PIXE for Manuscripts
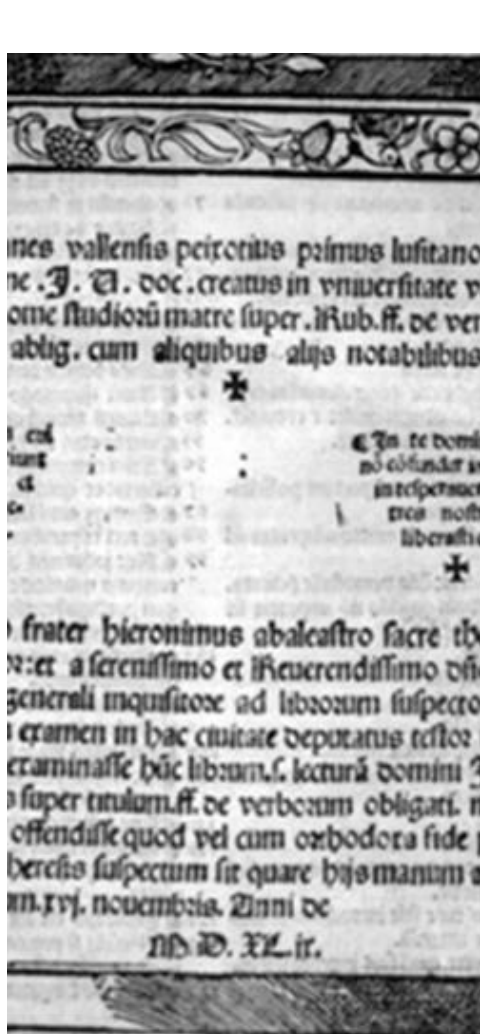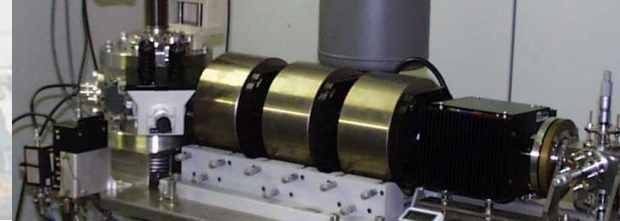
- Ink composition according with the date/location
- Degradation due to external agents
- Ink composition homogeneity
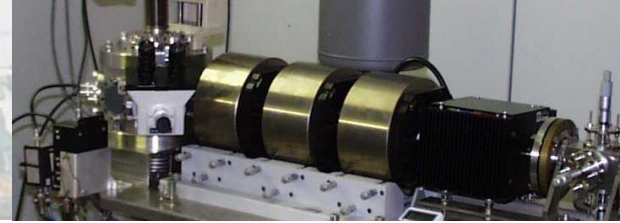- Ink-parchment detection

PIXE at CTN
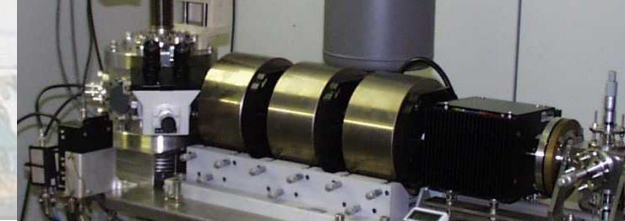
The Research Group is working in IBA techniques since 1982, using an 2,5 MV Van de Graaff. For PIXE experiments an Oxord Microbeams - Ion microprobe with a lateral resolution of 1,5 µm is used.
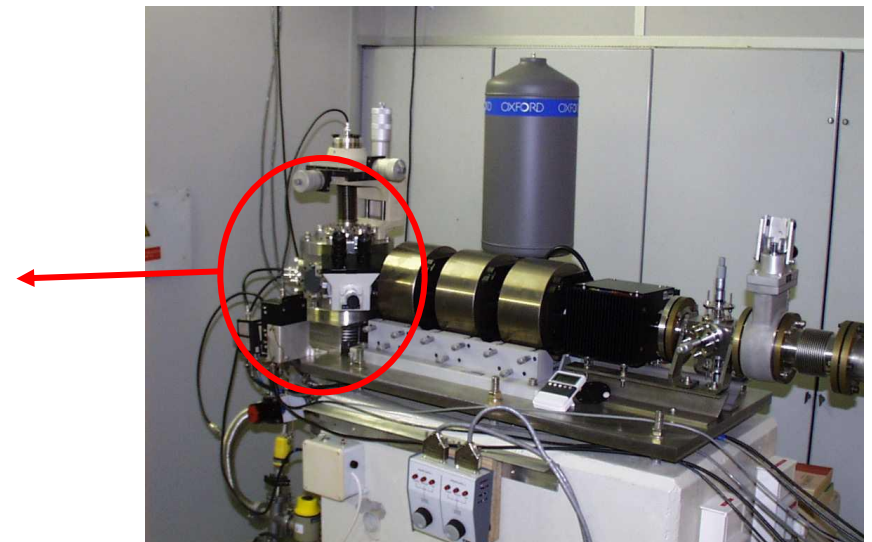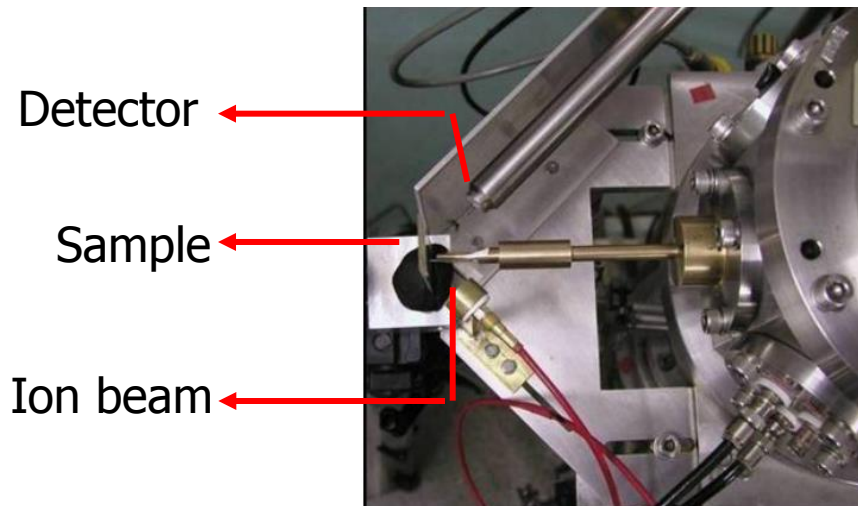
External - PIXE at CTN

The external microbeam for PIXE experiments is available since 2008. Since then, multiple studies in Cultural Heritage have been performed in collaboration with Universties, Museums...

Examples: Arraiolos tapetries, Roman glasses, Monasterio da Batalha stained glasses, jewelry, ceramics, etc.

Detector

Sample

Ion beam
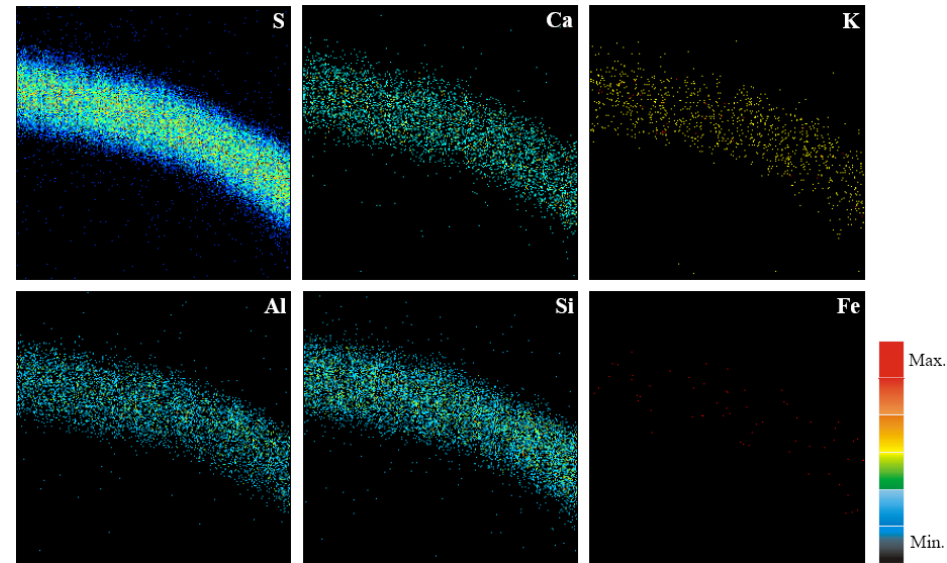
External-PIXE at CTN: Case Study

Arraiolos rug - 17th century - Portuguese Ancient Art National Museum collection (MNAA).

Colour hues can be obtained by using different mordants with the same dye.
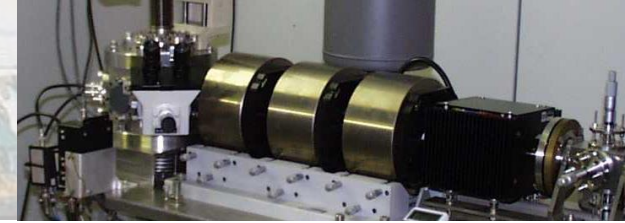
Wool composition: S, Si, Ca and K;
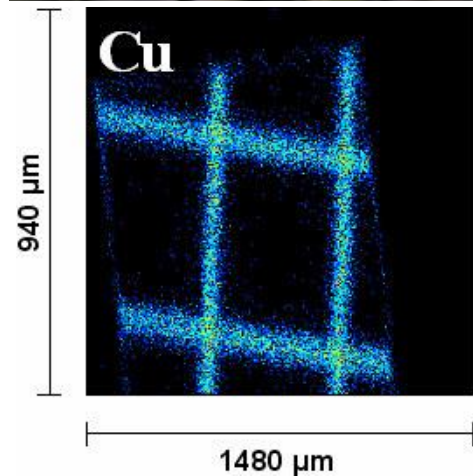
Presence of Al due to a pre-mordanting procedure;

2D elemental mapping by μ-PIXE of historical samples

PIXE at CTN: Team

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