



## Cultural Heritage Advanced Research Infrastructures: Synergy for a Multidisciplinary Approach to Conservation/Restoration



### Laboratory of Ion Beam Applications at ATOMKI-HAS

The Laboratory of Ion Beam Applications of ATOMKI-HAS is based on a home-made 5 MV Van de Graaff electrostatic accelerator. The available ions for analysis are as follows:  $H^+$ ,  $D^+$ ,  $^4He^+$ . The assortment of ions and their energy range makes it possible to apply most of the nondestructive ion beam analytical techniques used for the study of cultural heritage.

The infrastructure installed with four beam lines, three of which are included in the project:

- Particle induced X-ray emission (PIXE) technique done with a collimated ion beam for bulk sample analysis in the Mg-U atomic number range;
- Particle-Induced Gamma-ray Emission (PIGE) analysis performed either with proton ( $H^+$ ) or deuteron ( $D^+$ ) beam (often called DIGE) for the analysis of light elements (Li – Si);
- Microbeam analysis of microsamples with high lateral resolution (in the range of 1  $\mu m$ ) using the above mentioned PIXE & PIGE techniques completed with techniques detecting particles (RBS, NRA & ERDA) for the study of stratigraphy, 2D tomography and hydrogen content of the samples .

### Services currently offered within FIXLAB

The most important technique offered to access by ATOMKI-HAS is the scanning nuclear microprobe facility (Fig. 1.). As in the field of cultural heritage the samples are usually not uniform therefore the available beam size down to 1  $\mu m$  allows micro analytical investigations & mapping with high lateral resolution.

The sample chamber is equipped with a world leading and unique detector set-up including an ultra thin windowed and a conventional Be windowed Si(Li) X-ray detectors for the simultaneous detection of elements from boron to uranium with a high sensitivity. For elemental depth profiling Rutherford backscattering (RBS) while for light element analysis Nuclear reaction analysis (NRA) also available simultaneously with PIXE. Elastic recoil detection analysis (ERDA) technique is applied for hydrogen detection. In special cases, various gamma ray detectors (HPGe, Clover-Ge-BGO) are available for PIGE analysis and depth profile measurements for light elements. Our recent software development (PIXEKLM-TPI package) leads to the determination of quantitative 2D concentration using a fundamental parameter method.

BEAMLINE /SET-UP	PARTICLES	E (MEV)	BEAM DIAMETER	I (nA)
Macro-PIXE	$H^+$	2	1-5 mm	0.1-30
Macro-PIGE/DIGE	$H^+$ , $D^+$	0.7-4	1-5 mm	0.1-30
Nuclear Microprobe	$H^+$ , $D^+$ , $He^+$	1-3.5	1 $\mu m$	0.01-1



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**Figure 1:** The ATOMKI-HAS Oxford-type nuclear microprobe. The sample chamber is equipped with a 5-axis goniometer, 2 X-ray detectors and particle detectors making available high lateral resolution elemental analysis simultaneously.

Contact Person:

Name: Dr. Aliz SIMON

Telephone: (+36)52509211 – Fax: : (+36)52416181,

Email: a.simon@atomki.hu