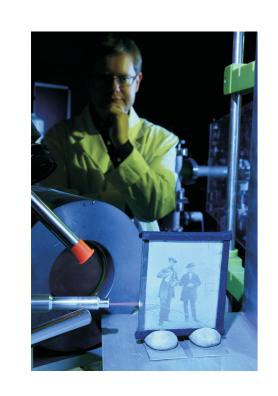# Recent upgrades of the external beamline at MIC

DAVID JEZERSEK, univ. dipl. met. in mat.
Study programme: Nanosciences and Nanotechnologies
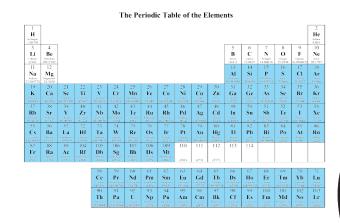Jožef Stefan International Postgraduate School
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Schematics of Tandetron, 2MV ion accelerator at MIC

elements detectable by PIXE method

elements detectable by PIGE method
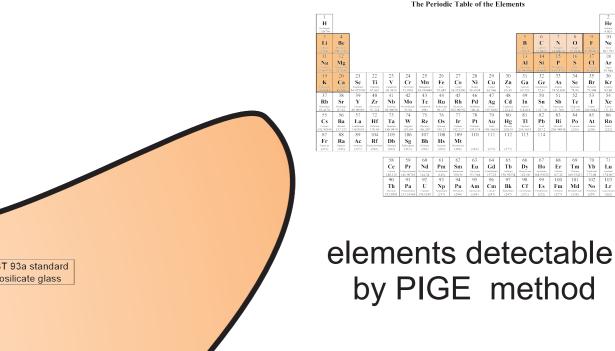
PIGE

Proton **I**nduced **G**amma-ray **E**mission

Detection of light elements through production of gamma rays in a proton induced nuclear reaction.

Ion beam analysis

("IBA") is an important **family of modern analytical techniques** involving the use of MeV ion beams to probe the composition and obtain elemental depth profiles in the near-surface layer of solids. All IBA methods are highly sensitive and allow the **detection of elements** in the sub-monolayer range. **Atomic depth resolution** can be achieved, but requires special equipment. The analyzed depth ranges from a few ten nanometers to a few ten micrometers. IBA methods are always **quantitative** with an accuracy of a few percent. Channeling allows to determine the depth profile of damage in single crystals.
(source: Wikipedia)

PIXE

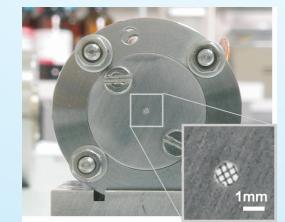**P**roton **I**nduced **X**-ray **E**mission

PIXE is an ion-beam based analysis method capable of measuring concentration of multiple elements heavier than Al simultaneously. Detection limit for most elements is around 10ppm and detection depth is around 100um.
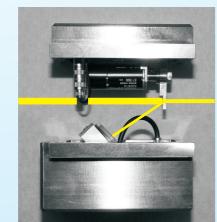
$$Y_i = \frac{\Delta\Omega}{4\pi} N_p N_A \frac{\varepsilon_i \eta_i \sigma_i^x}{M_i} \frac{q_i}{\cos\alpha}.$$

Normalization (measuring N_p)

Basic parameter for obtaining quantitative results is a number of ions (protons) which hit the target (Np). There were two possibilities for measuring the proton dose added recently at the external beamline at MIC, wire mesh and chopper.

Platinum **wire mesh** (Pt90Rh10) intersects the ion beam and collects charge which is proportional to the charge (number of protons) deposited on the target[1].

Chopper is a gold plated piece of carbon, which intersects a proton beam periodically. Some protons are recoiled into the RBS detector. Surface of Au peak is proportional to the proton dose on the target.
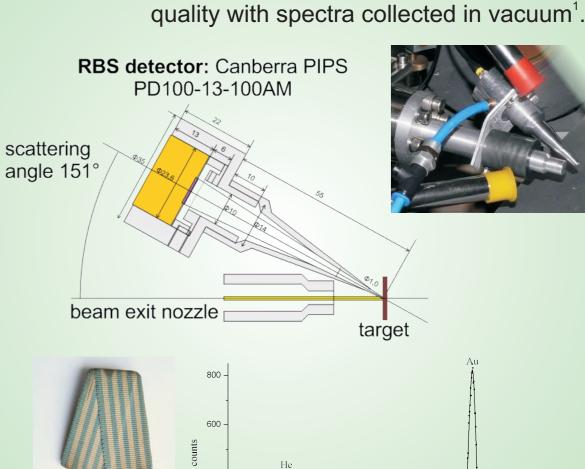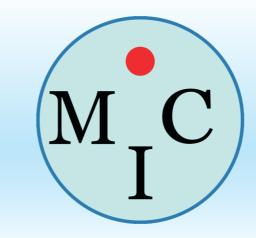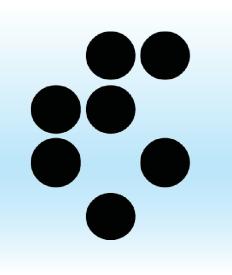
Au peak

RBS

Rutherford **B**ack **S**cattering

Simple system for RBS measurements in He atmosphere was made at MIC. Resulting spectra are of comparable quality with spectra collected in vacuum[1].

RBS detector: Canberra PIPS PD100-13-100AM

scattering angle 151°

beam exit nozzle   target

Depth resolution

With an RBS method we can easily detect layers of heavier elements on the substrate of lighter elements and determine its thickness.

RBS spectrum of gilded medal of bravery from II world war. Thickness of gold layer is 0.4 µm.

Where?

Microanalytical **C**entre   http://www.rcp.ijs.si/mic
Ion Accelerator: HV 2MV Tandetron
Department for Low and Medium Energy Physics
at Reactor Centre Podgorica
Jožef Stefan institute.

What?

External beamline

- in-air proton beam,
- measurements of samples not suitable for vacuum (e.g. liquids, big, delicate objects)
- use for analysis of samples for:
    - Archaeology (metal and glass artefacts, pottery, wood...)
    - Art (paintings, glass work, ...)
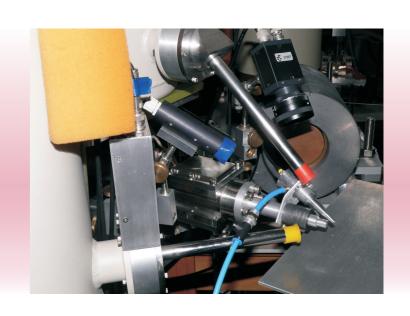   - Forensics (measurement of fibres[2])

REFERENCES:
[1] D. Jezeršek et al. External beamline setup for plated target investigation, *Nucl. Instr. and Meth. B* (**2010**), doi: 10.1016/j.nimb.2010.02.118
[2] D. Jezeršek et al. Analysis of textile fibers by in-air PIXE, *Surface and Interface Analysis* (**2010**), Vol 42, Issue 5, pp. 358-362.