



NEW FACILITY OF NEUTRON RADIOGRAPHY AND TOMOGRAPHY AT THE WWR-SM REACTOR (INP AS RUz, UZBEKISTAN): CURRENT STATE AND FIRST RESULTS

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Institute of Nuclear Physics of the Academy of Sciences of the Republic of Uzbekistan

Cyclotron U-150-II



Cyclotron U-115



X-ray diffractometer



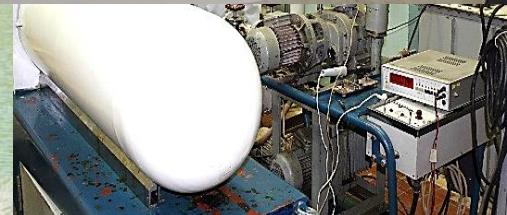
Scanning probe microscopy (SPM)



Electronics U-003



Gamma setting



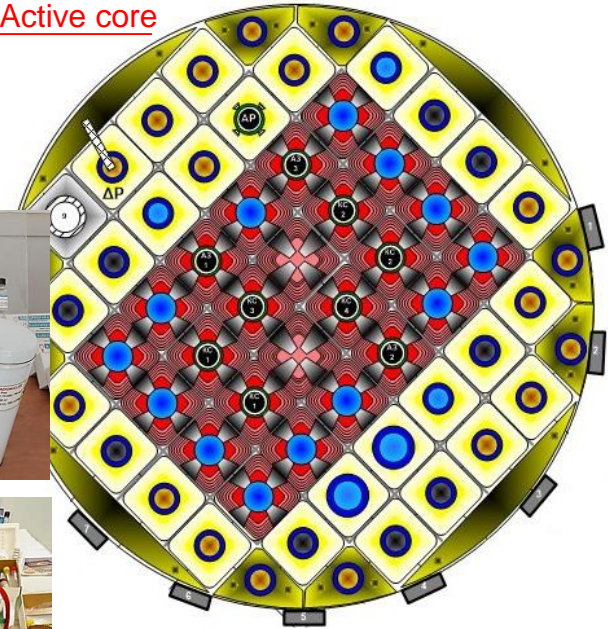
Neutron generator NG-150

WWR-SM research reactor

Experimental hall



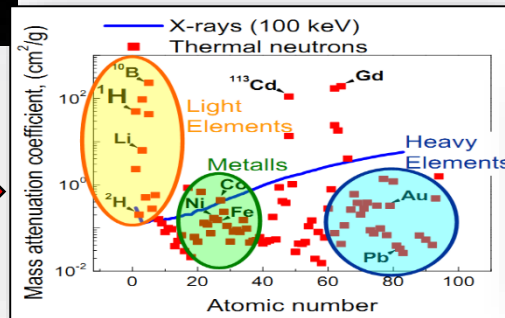
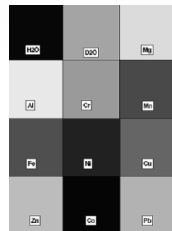
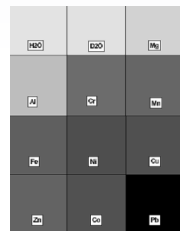
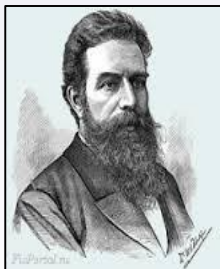
Active core



Beamlines:
horizontal (radial) - 9
thermal column - 1
Vertical - 42

Neutron imaging

The neutron radiography and tomography advantages



X-ray neutrons



X-ray

neutrons

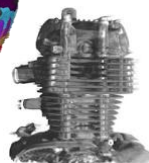
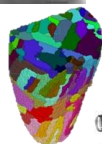
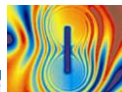
✓ Nuclear interaction



Eberhard H. Lehmann et al. *Archaeometry*, 52(3), 416–428 (2009).

Kardjilov, N., et al. *Neutron Imaging. Neu. Scat. App. and Tech.*, 329–349 (2016).

✓ Magnetic interaction



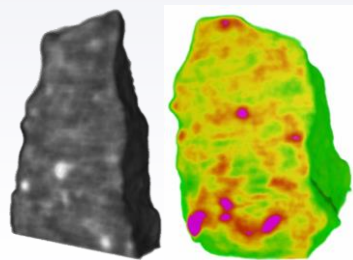
✓ High penetration



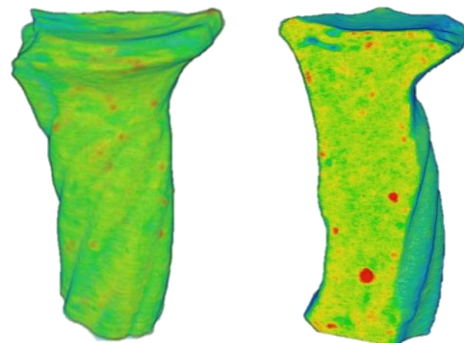
Neutron radiography and tomography

Non-destructive structural diagnostic methods

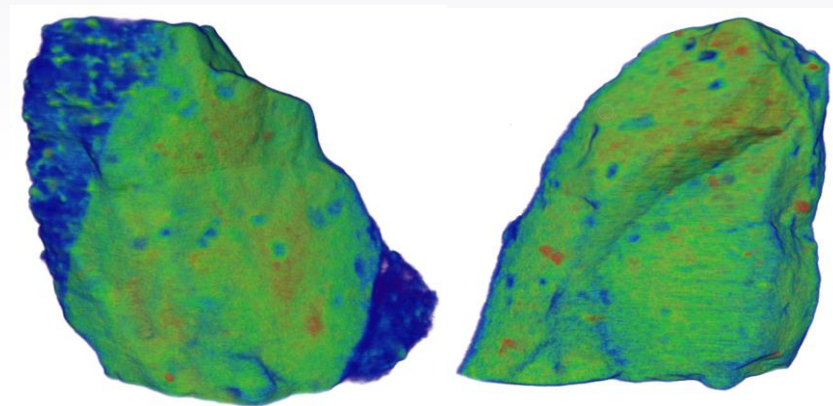
- ▶ Astrophysics
- ▶ Geophysics
- ▶ Engineering
- ▶ Plant science
- ▶ Paleontology
- ▶ Cultural heritage



Chelyabinsk meteorite



Ancient Romanian pottery



Lamprophyre dikes from Koitash granitoid intrusion (Uzbekistan)

S.E. Kichanov, ..., B. Abdurakhimov et al. *SN Applied Science*, 1 (2019) 1563.
B.A. Abdurakhimov et al. *J. Archaeol. Sci.: Rep.*, Vol. 35, (2021) 102755.

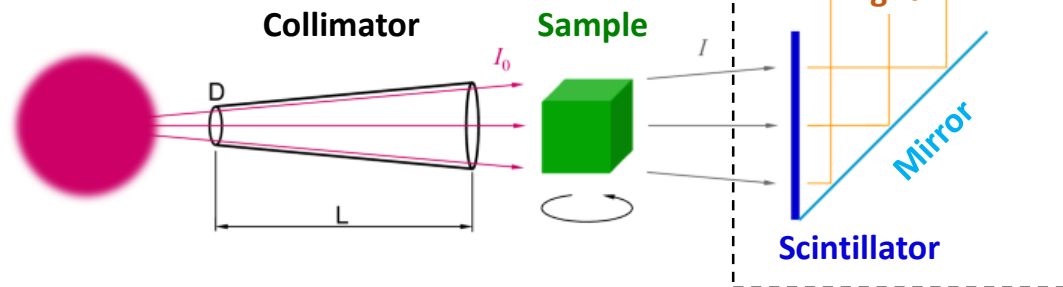
The generic neutron imaging facility

A generic neutron imaging (NI) facility consists of four major components:

- ▶ the neutron source, including moderation media and filters
- ▶ the beam forming equipment (collimation)
- ▶ the sample environment
- ▶ the neutron imaging detector



Neutron source



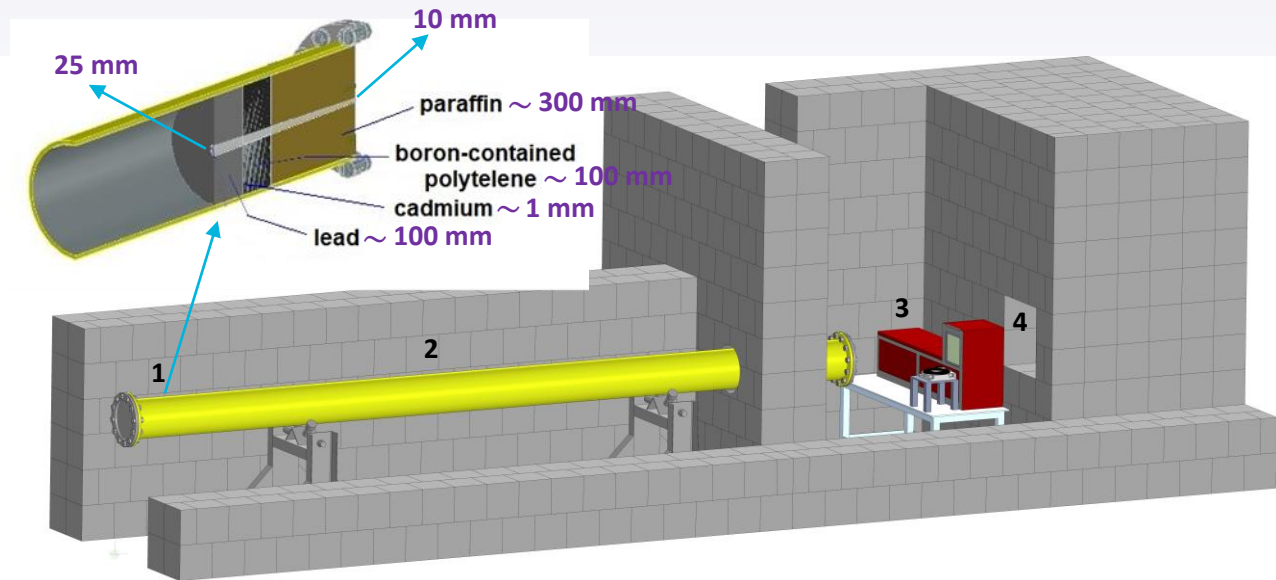
The layout of the neutron imaging facility

1- collimator system

2- evacuated tube

3- detector system
and goniometer
position

4- concrete
biological shielding
and beamstopper

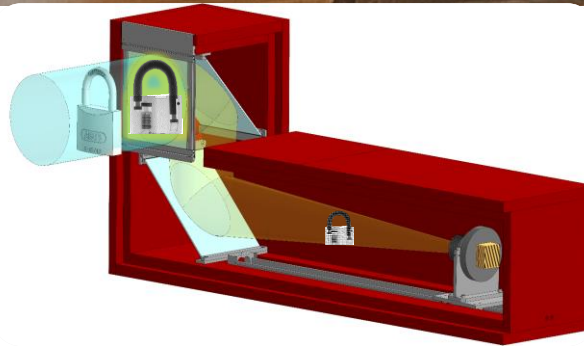
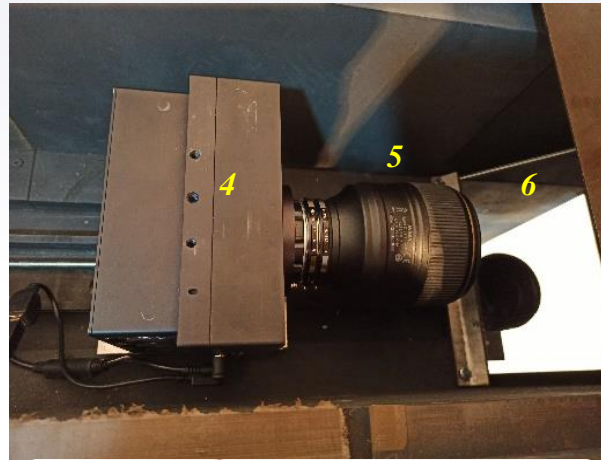


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Detector system



- 1- light-tight boron-contained polyethylene box
- 2- scintillation screen position
- 3- Standa rotation goniometer
- 4- CCD camera
- 5- optical lens
- 6- mirrors

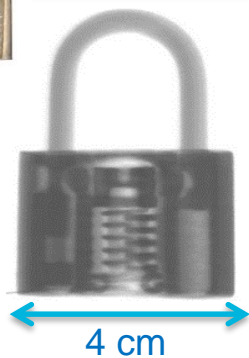


Parameters of neutron imaging station

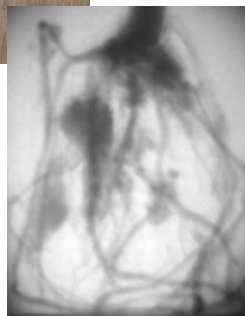
| | |
|-----------------------------|--|
| L/D ratio | 600 |
| Field-of-view | 90 × 90 mm ² |
| Scintillation screen | ⁶ LiF/Zn(Cd)S: Ag thickness 0.2 mm |
| CCD camera | ON Semi KAF-9000 3056 × 3056 pixels 12×12 μm 36.6 × 36.6 mm |
| Lens system | Nikon 105 mm 1:1.4D AF-Nikkor |
| Spatial resolution | 280 μm |
| Neutron flux | 9×10 ⁶ n/cm ² xs |

Test experiments. First images

Neutron radiography

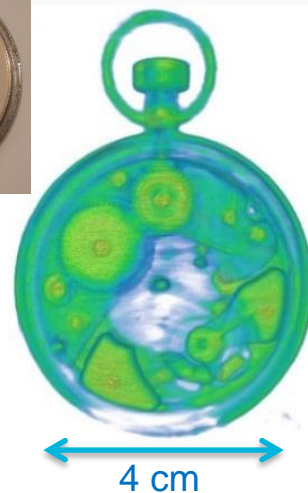


| Metal padlock



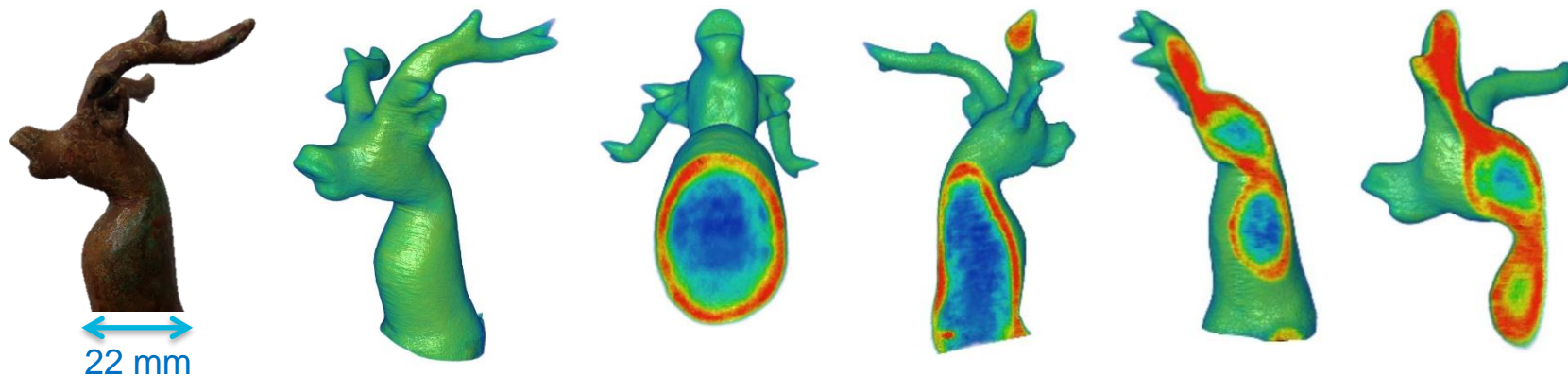
| Corn plant in a aluminum container

Neutron tomography



| Photo and reconstructed 3D model of the stopwatch. The rainbow-like coloring codes the attenuation coefficients of the neutron beam from low (green) to high (red)

Application of neutron imaging

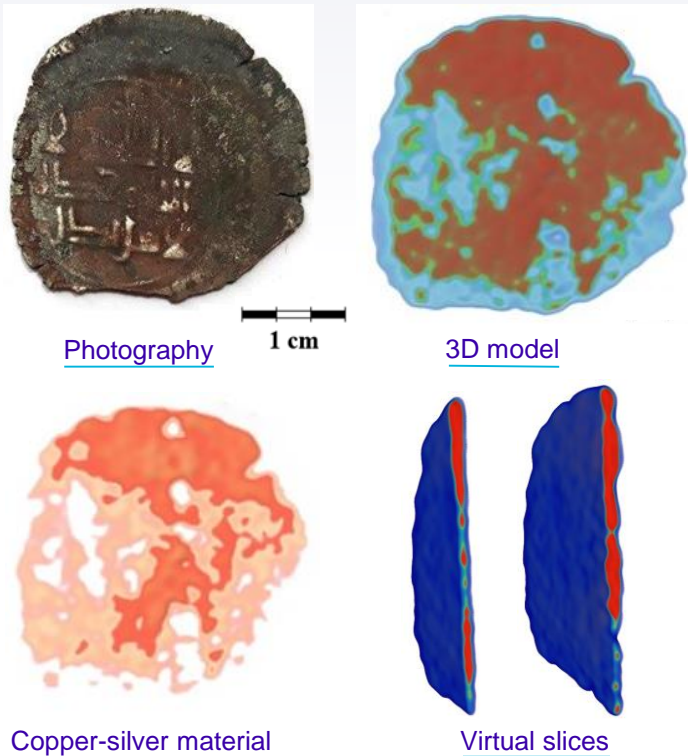


Bronze deer-shaped incense burner. This bronze object is dated to the III-IV centuries A.D. and found at the archeological site around the Dalvarzintepa settlement of the Surkhandarya region of Uzbekistan.

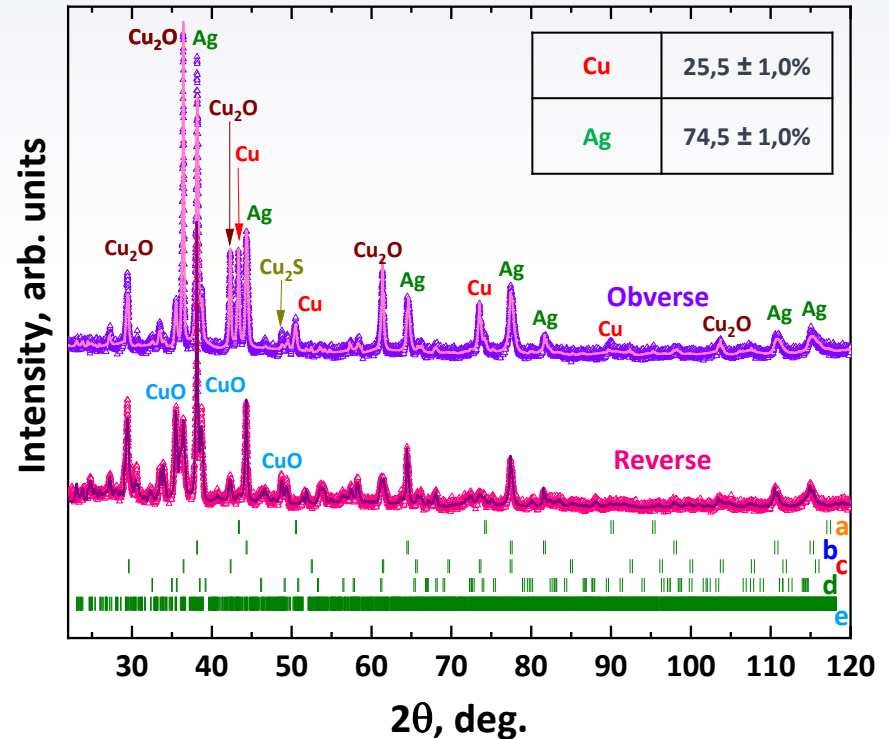
The 3D model after the tomographic reconstruction procedure. Different virtual slices of the obtained 3D model as examples. The rainbow-like coloring shows the attenuation coefficients of the neutron beam from low (green) to high (red).

Application of neutron imaging

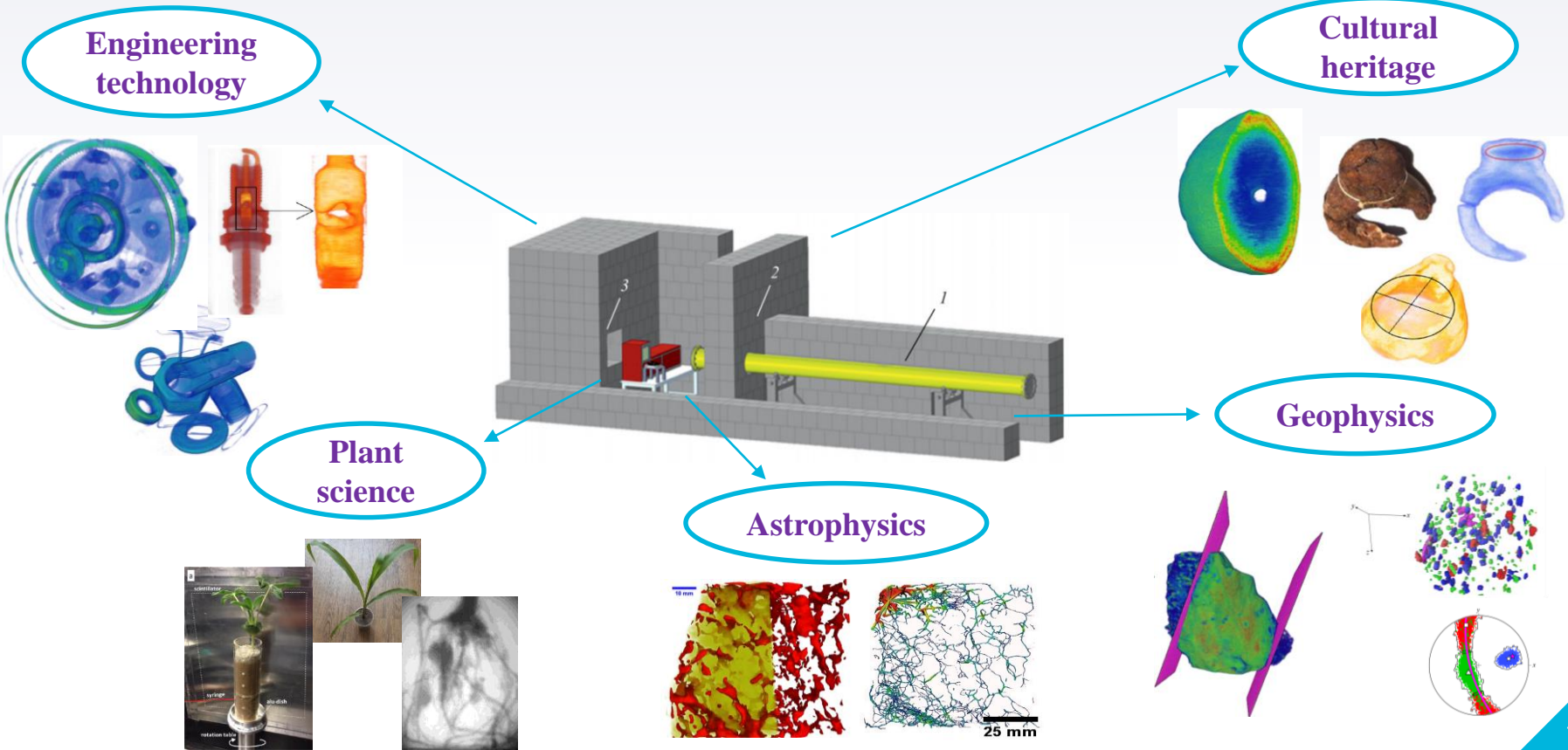
Neutron tomography



X-ray diffraction



Future plans



Bactrian fortress of Uzundara

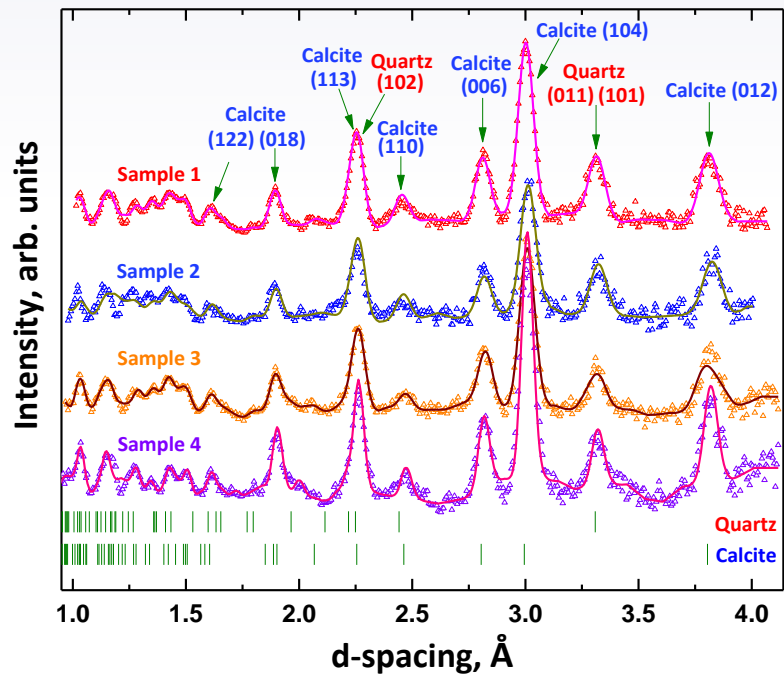
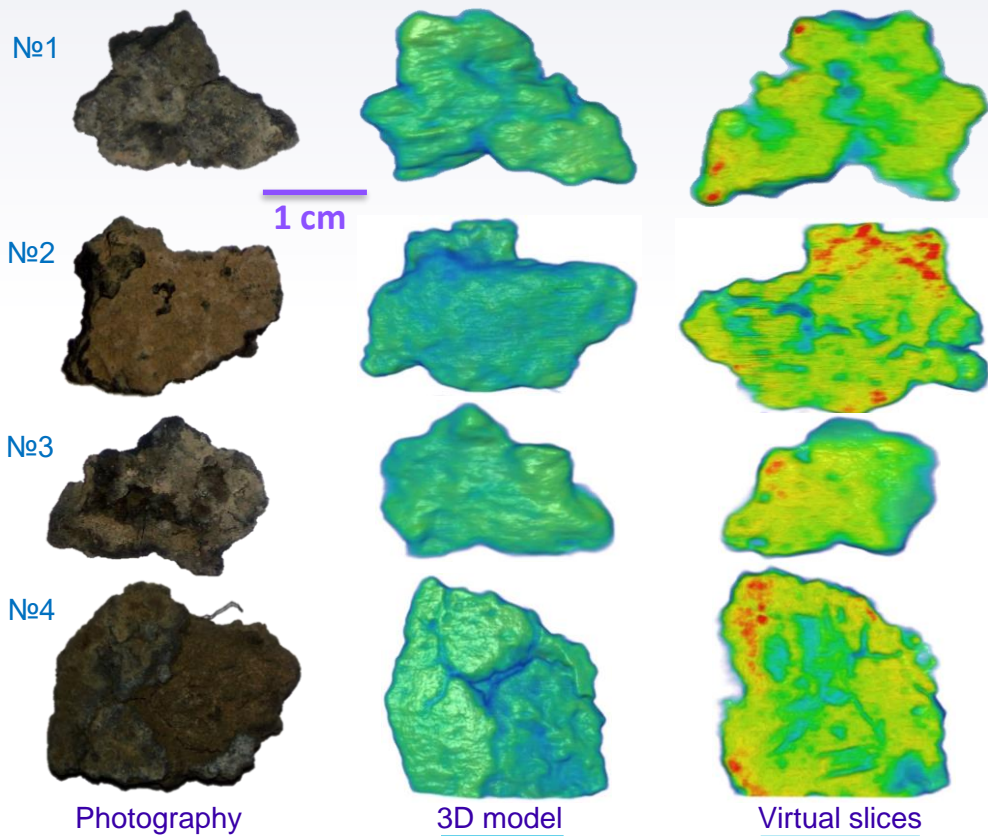


Alexander the Great and Roxana,
a 1756 painting by *Pietro Rotari*.

Artifacts from the fortress of Uzundara



Neutron tomography and diffraction results



Joint JINR-INP AS RUz working team



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Academician,
President of AS RUz



M.Yu. Tashmetov
Deputy director of
INP AS RUz



N.B. Ismatov
Senior researcher



A.R. Saidov
Senior engineer



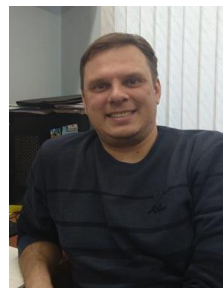
V.N. Shvetsov
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THANK YOU FOR YOUR ATTENTION!

