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Introduction

Neutron imaging is a non-destructive investigation method with a fast growing application field in materials research and fundamental science. The method is used broadly in the cultural heritage research as complementary technique to x-ray imaging. The ability of neutron beam to transmit thick layers of metal and the sensitivity to light elements makes the technique unique for detection of organic substances in metal and stone matrices. The high penetration power of neutrons allows for investigation of samples with real dimensions of about 100 cm^3. The neutron imaging in cultural heritage helps to provide information about manufacturing processes and material properties which is very important for further restoration and conservation of the objects. The development of new methods like energy selective imaging and grating interferometry and the application of autoradiography increase the potential of the method for characterization of cultural heritage samples.

The neutron tomography instrument CONRAD has been in operation since 2005 at the Hahn-Meitner research reactor at Helmholtz-Zentrum Berlin (HZB). Over the last 5 years, significant development work has been performed to expand the radiographic and tomographic capabilities of the beamline. New techniques have been implemented, including imaging with polarized neutrons, Bragg-edge mapping, high-resolution neutron imaging and grating interferometry. These methods together with the autoradiography have been provided to the user community as tools to help address scientific problems particularly in the field of cultural heritage and palaeontology. Descriptions and parameters of the facilities are given below.

Experimental facility:

Imaging facility CONRAD at HZB: the neutron tomography station at the Hahn-Meitner research reactor at HZB is installed at the end of curved neutron guide. The guide has a radius of curvature of 750 m, which provides a flux density of $2x10^9$ $n/cm^2/s$ while minimizing thermal neutron and gamma radiation noise to the instrument. The cold neutron beam is used beside the conventional absorption contrast radiography and tomography for imaging with polarized neutrons, energy-selective mapping, grating interferometry and high-resolution imaging. The flexibility of the instrument allows for switching between different modes in a matter of only a few hours. Beam collimation is performed by means of pinhole geometry, using a pinhole exchanger which is placed at the end of the neutron guide. The distance from pinhole to the downstream sample position is 5m. Using circular pinholes with diameters of 1 cm, 2 cm and 3 cm, mounted in 5 mm B_4C neutron absorbing plastic, beam collimation ratios (L/D) rates achieved are respectively 1000, 500 and 333. A neutron imaging detector system based on a CCD camera was implemented at the CONRAD instrument. The CCD camera used is an Andor DW436N-BV 16-bit CCD camera with 2048×2048 pixels and a pixel size of 13.5 µm × 13.5 µm. Conventional scintillating screens (^{6}LiF/ZnS:Cu,Al,Au) were used. The entire detector assembly is situated in a light-tight box. This detector system allows for a range of imaging capabilities, from a maximum field of view (FOV) of 20 cm x 20 cm at a spatial resolution of 250 µm, to a high resolution of 70 µm with a FOV of 6 cm x 6 cm.

Facility for neutron autoradiography B8: The instrument B8 allows to irradiate and activate artistic, technical or geological items (foils, stones etc.) and other materials with cold neutrons and to investigate them by imaging plate technique and/or to analyse it by gamma-spectroscopy. In the main the instrument is used for paintings but also for other purposes (neutron activation analysis). The painting is fixed on a support in front of a neutron guide end with an open area of 3.5 x12.5 cm^2. The surface of the painting is adjusted under a small angle (< 3°) with respect to the axis of the guide. Thus a 12.5 cm wide strip of the painting is illuminated by the neutrons. The main free path of the neutrons within the paint layer is much longer than in the case of perpendicular transmission. The support is moved up and down with a velocity of a few cm/s in order to receive a uniform activation of the total area of the panel. The facility is installed in a secure closed container. The basic area of the container is 250 x 450 cm^2. On a special table in a shielded room in the basement the film exposure and the gamma spectroscopy can be performed for the suitable times (up to more than 4 weeks) depending on the half-lives of the isotopes.

Workplan year 1:

– Establishment of contacts with partners from cultural heritage institutions (museums, archaeological and paleontological groups).
– Identification of interesting scientific questions and definition of scientific projects with different partners.
– Conventional neutron tomographic and autoradiographic experiments on target objects.
– Data evaluation and decision if innovative methods are needed for further investigation.

Main objective	**Sub objectives**	**Year 1**				**Year 2**				**Year 3**			
		Q1	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
Contact with CRP partners and museums	CRP partners	X											
	Museums		X										
	Identification of samples			X	X								
Measurements by conventional tomography	Quantification				X	X							
Measurements by energy-selective imaging	Quantification					X	X						
	Phase separation						X	X					
Measurements by grating interferometry	Metals						X	X					
	Glass							X	X				
	Geological samples								X	X			
Measurements by laminography	Large samples									X	X		
	Flat samples										X	X	
Autoradiography	Test samples				X			X		X		X	
Reporting and publish the results	Report											X	
	Publications												X