# NEUTRON RADIOGRAPHY STUDIES FOR CULTURAL HERITAGE WITHIN THE NEU_ART PROJECT

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keywords: neutrons, radiography, imaging

## ABSTRACT
One of the aims of neu_ART project is to investigate the capability of fast neutron imaging applied on artefacts of interest for cultural heritage. Compact systems based on D-D or D-T fast neutron sources could be installed in certificated laboratories near restoration centers as diagnostic tools to plan the restoration work. This paper presents preliminary studies carried out at fast (NECTAR) and thermal (INES) neutron facilities. Custom samples of different thicknesses, internal structures and material compositions were analyzed, together with artistic objects to compare the performance of fast and thermal neutron radiography. We focused our studies on the neutron penetration into metals, as bronze, iron, and brass. A detailed analysis of the results is presented and compared with digital X-ray radiography. These two complementary techniques can be integrated to fully characterize the objects under study.

## INTRODUCTION
The imaging potential of cold and thermal neutrons has been assessed in the cultural heritage field. They allow non-destructive analysis [1], can penetrate thick layers of materials and permit to determine the presence of low Z elements within metals. Fast neutrons provide similar information especially when thick or dense materials are involved [2].
At present commercial compact neutron generator based on D-D or D-T fusion reaction are available. They consist mainly of a source to generate positively charged ions, one or more structures to accelerate the ions (usually the acceleration voltage lies between 100 kV – 400 kV), a metal hydride target loaded with deuterium, tritium, or a mixture of the two. These generators provide fast neutrons (2,5 MeV or 14 MeV when D-D or D-T reactions are used respectively) and reasonable neutron yield [3]. Feasibility studies are in progress within the framework of the regional project neu_ART [4] to assess and better exploit the capabilities of these neutron sources.
This paper presents a preliminary work focused on the comparison of fast and thermal neutron radiography technique applied on different artistic handworks. The results are also compared with digital X-ray radiographies, which provide complementary information on the inner structure of the artefacts.

## 1 METHODS
### *1.1 Physics*
The dominant interaction of a neutron beam penetrating the matter is with the atomic nuclei. The total microscopic neutron cross section of each element is related to the interaction probability and is a function of the neutron energy. As it is shown in Figure 1 (left) the cross section decreases steadily