# Fast-Neutron Tomography Techniques for a Mixture of High and Low Z Materials

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## 1. Introduction

Neutron radiography can provide a better contrast than X- and gamma-rays, because neutrons can pass with ease through lead and steel but are stopped by polymer, plastic, rubber, water, oils, etc [1-3]. This means that neutrons are attenuated by hydrogen composite, but penetrate many heavy materials such as tungsten and lead.

Especially, fast-neutron imaging radiography and tomography techniques are really attractive for industrial applications, because of theirs discrimination abilities in complexing substances mixed with high Z and low Z materials [4-6].

This work is a feasibility study of distinguishing abilities of fast-neutron imaging of different features in complex objects composed of a mixture of high Z and low Z materials. In this experiment, it would be the study of the attenuation of the beam intensity as the comparison of the neutron penetration capabilities with fast neutrons above 1 MeV.

For this work, an experiment for finding defects on the surface of material with low-Z inside a thick steel box has been performed by means of fast-neutron tomography technique at the NECTAR (NEutron Computed Tomography And Radiography) facility at the Research Neutron Source Heinz Maier-Leibnitz (FRM II) in Garching (Germany).

## 2. Experimental setup

A feasibility study of fast-neutron tomography for a mixture of high and low Z materials has been carried out at the NECTAR facility located at the FRM II nuclear research reactor. The FRM II is under the continuous operation of 20 MW. The total neutron yield is $10^{13}$ cm$^{-2}$ s$^{-1}$. The fast-neutron flux having averaged 1.8 MeV neutron energy at the device position was estimated to be about $10^{7}$ cm$^{-2}$ s$^{-1}$.

Fig.1 shows the experimental setup at the NECTAR. High-resolution fast-neutron imaging can be derived from the combination of highly collimated neutron beam, exact converting from neutron beams to fluorescent light through a scintillator and exact image formation through a CCD camera [7]. As for the neutron beam collimations, the beam collimation gets better as the distance from source increases, but beam intensity decreases quadratically as the distance increases. In actual case, the collimation is limited to have a certain divergence angle by the light responsibility of the camera.

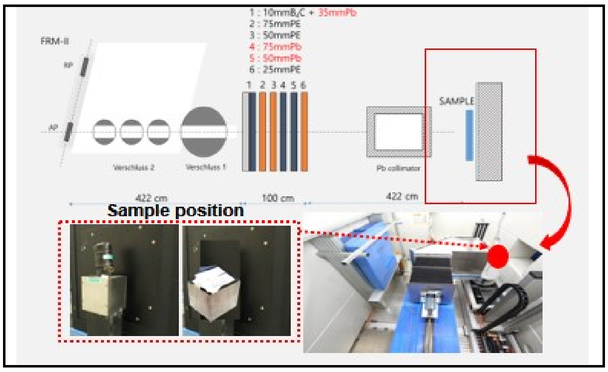

Figure 1 A collimator geometry for fast-neutron imaging at the NECTAR

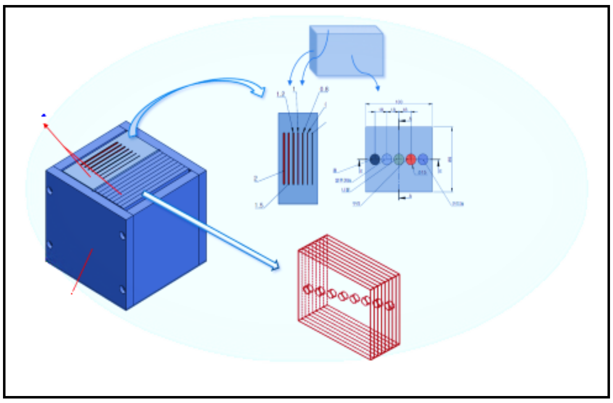
Figure 2 Drawing of a mixture of high (steel box) and low Z materials (PE plates) to be used as test sample for fast-neutron tomography

In order to investigate distinguishing abilities of fast-neutron imaging of different features in complex objects composed of a mixture of high Z and low Z materials, PE plates of 8 sheets were placed on inside of the steel box as shown in Fig.2. The steel box was made of SUS304 with thickness of 10 mm. The PE plates were also designed to investigate penetration and discrimination abilities of the 10 mm thick steel box. The PE plates were drilled a hole in a different position for each plate.

## 3. Results

The fast-neutron tomography was measured at the NECTAR. The exposure time was also 120 seconds. The object was rotated with a full 360 degree in order to obtain 1300 images. The captured results of the fast-neutron tomography images after reconstructed for 1300 images are shown in Fig.3.

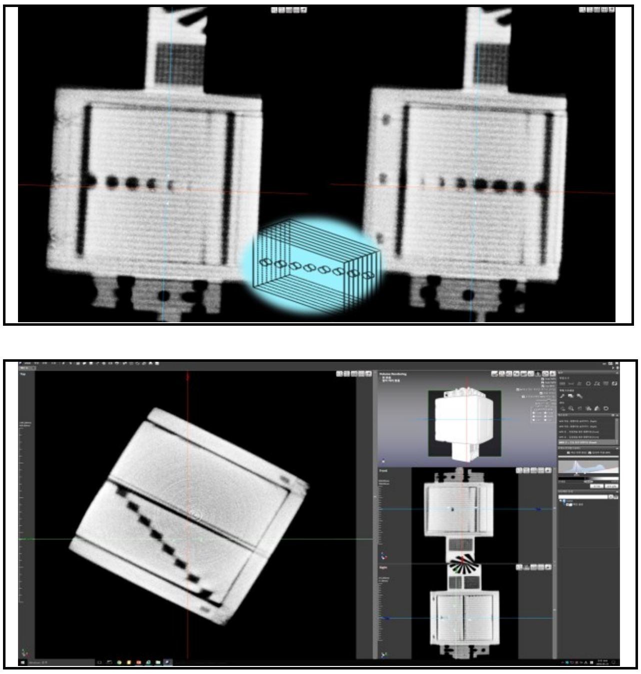

Figure 3 Fast-neutron tomography for the steel box filled with PE plates at the NECTAR

Due to the lower neutron energy at the device position, and low exposure time, the spatial resolution of the digital image is obviously not very good. Also the contrast of the presented image appears rather moderate. However, a more careful image analysis like flat correction, background subtraction, dead and hot pixel removal and further image processing will be able to improve those considerably.

## 4. Conclusions

A study of fast neutron tomography technique for a mixture of high and low Z materials has carried out at the NECTAR.

In conclusion, the fast-neutron tomography technique shows that it is possible to confirm the potentials of fast-neutron tomography technique in complex objects composed of a mixture of high and low Z materials, and that it can also be utilized for industrial applications.

The present result is rather preliminary and further study will be needed.

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## ACKNOWLEDGEMENTS

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