11th World Conference on Neutron Radiography
WCNR-11
2-7 September 2018 | Sydney, Australia

Contribution ID : **123** Type : **Oral**

An experimental approach for quantitative scattering correction in neutron imaging.

Thursday, 6 September 2018 14:30 (20)

Introduction
Quantitative neutron imaging is hampered by different sources of nonlinearity: polyenergetic beam, beam hardening, detector uneven light distribution and neutron scattering. The correction of these effects is necessary to approximate the log-attenuation as a linear function of the sample density. We focus here on the scattering component, caused by the neutron interaction with the sample and with the experimental apparatus. We recently proposed a fully empirical method for scattering correction without the need of prior knowledge of the neutron spectrum or of the sample composition [1]. We describe here its implementation: a scattering correction term is included into the post-processing image normalization procedure, which usually only includes open beam and dark current images.
We show the performance of the proposed approach in removing scattering related cupping artifacts in a test CT acquired at the NEUTRA beamline at PSI.
Methods
An aluminum frame containing neutron absorbing cylinders made of 10B4C, called black bodies (BBs) evenly distributed over the field of view has been constructed. As the BBs are opaque to neutrons, the measured neutron intensity behind them can be interpreted as the scattered neutrons component.
During the experiments, two more sets of images are acquired using the reference frame for the estimation of the scattered neutrons contribution to the image intensity: with and without the sample in the beam. These images are used to correct for the scattering contributions from the sample and the background, respectively. The scattering component is estimated from the BB measurements by segmenting the BBs and interpolating the underlying values with a 2D second order polynomial scheme. A dedicated dose correction scheme is also implemented to compensate for beam fluctuations and the decrease in transmission due to the presence of the BB grid. The computed scattering components are subtracted from projections and open beam images, before image normalization.
The necessary image processing and implementation of image normalization is integrated in MuhRec, an open source CT reconstruction software [2].
Results and discussions
A cylindrical aluminum container (10 mm external diameter, 2 mm thick) filled with water was imaged at NEUTRA measuring position II with 625 tomographic projections uniformly distributed over a full rotation of 360deg (100 µm thick 6LiF/ZnS scintillator). BB images were taken without the sample and with the sample according to a sparse CT scheme (25 equally distributed projections over 360deg) and linear interpolation was applied to estimate sample scattering in missing angles. With the proposed approach, the cupping artifacts in the reconstructed CT were successfully compensated. Mean attenuation coefficients were around 3.57 cm-1 for corrected vs. 2.84 cm-1 for the non-corrected CT (expected value 3.6 cm-1).
References
[1] Boillat P, Carminati C, Schmid F, Gruenzweig C, Hovind J, Kaestner A, Mannes D, Morgano M, Siegwart M, Trtik P, Vontobel P, Lehmann EH "Chasing quantitative biases in neutron imaging with scintillator-camera detectors: a practical method with black body grids" Optics Express, *submitted for publication*
[2] A.P. Kaestner "MuhRec – A new tomography reconstructor" Nuclear Instruments and Methods in Physics Research A 651, 156-160, 2011

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Session Classification : Speaker Sessions and Seminars

Track Classification : Methods