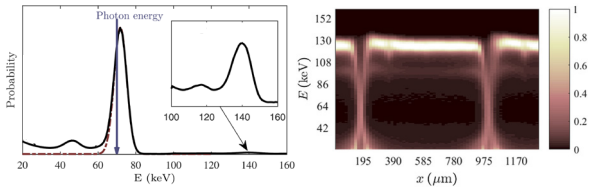
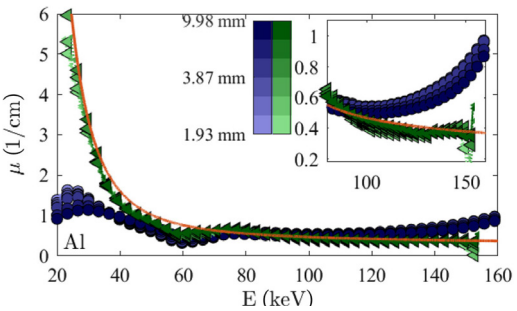
Evaluating a multispectral X-ray detector

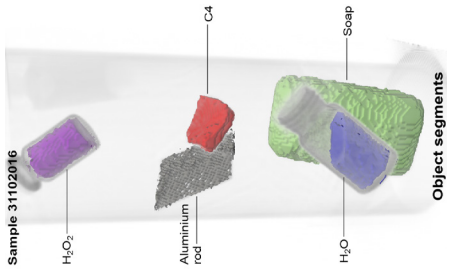
The company Exruptive works within the airport industry and aims at improving the process of X-ray scanning of cabin luggage - both by redesigning the current cabin luggage scanning process, and by raising the security level. The scanning system under development does not require passengers to divest liquids or electronics. Instead, by using a multispectral detector with both spatial and energy resolution, different materials can be identified easier, and with higher accuracy, than with current scanners. These multispectral detectors however have challenges regarding their spectral response, i.e. imperfections in the recorded energy. In order to be used effectively, the response therefore needs to be corrected. Exruptive got in contact with the 3D Imaging Centre at DTU to evaluate one of these multispectral detectors and to develop a method to correct the detector response.



a) Expected detector response (red, dashed) without other energy contributions, and measured spectrum (black, solid) with a monochromatic beam of 70 keV averaged over the full detector, i.e. without spatial resolution. b) Measured detector response at 123 keV as a function of readout energy and position of the beam on the detector. Ideally, only a peak at 123 keV would be obtained.



Attenuation curves of aluminium of different thicknesses (the darker the colour, the thicker the material). The measured, raw data are shown as blue circles. These corrected with the developed algorithm are depicted as green triangles and the ideal, expected attenuation curve for aluminium is shown as an orange line.



Energy-resolved 3D image of different materials in a cylindric container (grey). The colour corresponds to the different material labels assigned by the segmentation algorithm.

Challenge

Using energy-resolved X-ray detectors for X-ray tomography, the 3D image of a sample is reconstructed separately for each energy, which is why the energy spectrum at a given position at the detector needs to be correct in order to obtain a proper 3D image. The challenge was therefore to analyse the spectral response of the detector and develop a correction to account for issues based on other signal contributions.

Collaboration

Through the collaboration between the 3D Imaging Centre at DTU and Exruptive, the MultiX ME100 v2 was investigated both in-house at DTU, and at a joint beamtime at the European Synchrotron Radiation Facility (ESRF) in France. This collaboration was part of the LINX project in which researchers at leading Danish universities collaborate with scientists in industry to solve industry relevant problems using advanced neutron and X-ray techniques.

Results

The spectral detector response was analysed at different energies and different photon flux at the ESRF, to account for flux-dependent and flux-independent contributions to the spectral response. Amongst other measurements, the energy response was measured across a pixel to study how the signal varies within one pixel and at the border region inbetween two pixels, as shown in the top figure. As a result of the measurements performed at the ESRF and at DTU, it is possible to verfiy a semianalytical correction algorithm which accounts for the non-ideal contributions from the detector to the energy spectrum. It is therefore possible to correct the signal such that the correct energy is obtained, as it can be seen in the middle figure. An accurate energy-resolved material signature makes segmentation and classification possible, as shown in the bottom image.
For further information: doi: 10.1117/1.OE.57.5.054117

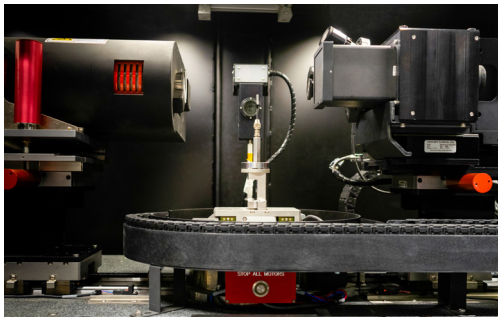
Perspectives

The correction tool allows Exruptive to use the detector effectively and therefore raise the detection probability and lower the false alarm rate for cabin luggage scanning.

Imaging Industry Portal

The Imaging Industry Portal is a part of the 3D Imaging Centre at DTU and assists companies in using and implementing 3D Imaging in research, development and production. The portal offers research-based 3D Imaging services and provides companies with the latest equipment and the most advanced knowledge within 3D Imaging and data analysis. The Imaging Industry Portal works as a gateway to ESS and MAX IV, as well as other large scale facilities.

www.imaging.dtu.dk/Industry-Portal



DTU 3D Imaging Centre