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Timepix3 based coded aperture camera for X-ray fluorescence surface mapping

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X-ray fluorescence surface mapping is a technique that enables non-invasive material identification of selected area on investigated specimen with just single exposure. The sample is excited at once with the primary cone-beam X ray source and fluorescent X-rays emitted from the surface are recorded through coded-aperture with position- and energy-sensitive detector. This approach eliminates the time needed for sample scanning with point-based mapping methods. The coded-apertures, similarly like the polycapillary x-ray optics, provide viable alternative to low efficiency pinhole collimator. This imaging technique originates from astrophysics but lately it has found its use in medical physics, natural and environmental sciences. We would like to extend the usage to the field of cultural heritage by this contribution.

We have used a custom build Timepix3 imaging camera dedicated for the X-ray fluorescence and scattering imaging. The detector is shielded by 4 mm thick tungsten carbide cover to avoid undesirable scattering signal from primary X-ray beam and the detector backplate contains water cooling system for detector temperature stabilization. The coded-aperture collimator is mounted in the modular objective that defines camera field of view. The hybrid pixel detector Timepix3 records full spectroscopic information about each photon in so called data driven mode enabling material identification based on their X-ray fluorescence energy.

The reference measurements were done with 50 and 100 μm large double-cone pinholes. The coded-aperture utilizes no-two-holes-touching (NTHT) pattern based on rank 17 modified uniformly redundant array (MURA). All collimators were laser drilled in tungsten plates. The pattern designs were evaluated by raytracing-based simulation and several reconstruction approaches based on pattern rotation, different deconvolution methods and iterative maximum-likelihood expectation-maximization (MLEM) were tested. Presented results cover both phantom objects measurements and cultural heritage samples.

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