Energy shift of the pink beam at the beamline ID19 measured with a grating interferometer and a liquid phantom

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INTRODUCTION: Grating-based hard X-ray phase tomography allows for the determination of the imaginary and real parts of the refractive index distribution[1] to three-dimensionally visualize soft and hard tissues.[2] Laboratory systems are easier accessible than tomography setups at synchrotron radiation facilities.[3] Therefore, conventional μCT-systems should also be equipped with a grating-based phase contrast setup. This is not as simple, because conventional X-ray sources produce a wide energy spectrum and the refractive index is energy-dependent. It is, therefore, reasonable to investigate the refractive index of phantoms at synchrotron facilities to determine the energy shift along the X-ray beam.

METHODS: For the quantitative comparison of reflective indexes a dedicated phantom containing >99.8 % ethanol and polypropylene was built and visualized using the grating-based phase tomography setup at the beamline ID 19 (European Synchrotron Radiation Facility Grenoble, France). The experiments were performed at the mean photon energy of 19.45 keV with 400 projections equiangular along 360° in four phase-steps over one period of the interference pattern.

RESULTS: The measured relative refractive index decrement $\Delta\delta$ depends on the photon energy. The comparison of the measured values $\Delta\delta_m$ with the predicted ones $\Delta\delta_c$ for each reconstructed slice of the homogeneous phantom enabled us to determine the photon energies along the rotation axis, which corresponds to the *y*-axis of the detector, see Fig. 1. The precise knowledge of the photon energy is essential to determine the electron density distribution of the objects of interest. The refractive index decrement of ethanol for the photon energy of 19.45 keV matching best the theoretical value of $-120.59 \cdot 10^{-9}$.was found in slice 301. Within a region of interest of 63 × 54 this value was $-(119.88 \pm 0.07) \cdot 10^{-9}$. To confirm the results the refractive index decrement of polypropylene of the same slice was determined to be $-(43.98 \pm 0.10) \cdot 10^{-9}$. This value fits well to the theoretical value of $-43.08 \cdot 10^{-9}$. The further data treatment is ongoing.

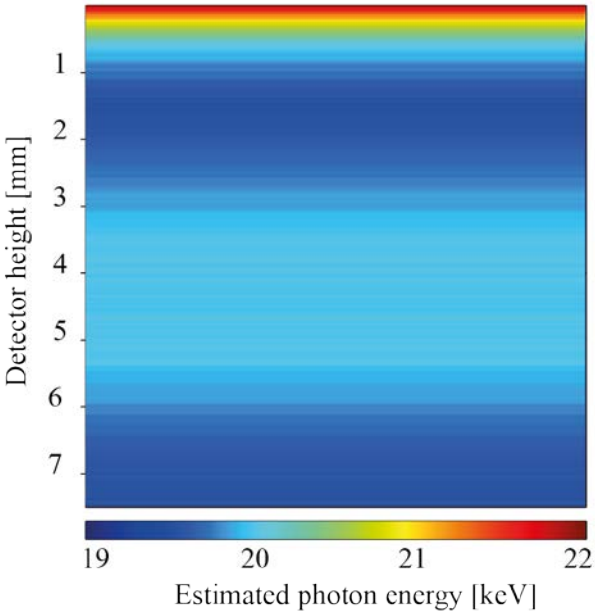

Fig. 1: Determined distribution of the photon energy along the rotation axis based on the calculation of $\Delta\delta$ of the ethanol-filled polypropylene phantom (239 × 281 pixels) measured with a mean photon energy of 19.45 keV.

DISCUSSION & CONCLUSIONS: Grating-based hard X-ray tomography of phantoms at a synchrotron radiation facility as necessary for the calibration of systems with conventional X-ray sources allows for the determination of energy shifts along the beam. Knowledge of energy shifts together with relative refractive index decrements could be used for the determination of electron densities of any material of interest more precisely. It is especially important for the visualization of soft tissues such as brain.

REFERENCES: [1] J. Herzen, T. Donath, F. Pfeiffer, et al (2009) *Opt. Express* **17(12)**:10010-18. [2] M. Holme, G. Schulz, H. Deyhle, et al (2014) *Nat. Protoc.* **9**:1401–15. [3] O. Brunke, K. Brockdorf, S. Drews, et al (2008) *Proc. of SPIE* **7078**:70780U.

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