Single grating X-ray phase-contrast tomography for evaluation of brain tissue degeneration on cellular level

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INTRODUCTION: Three-dimensional (3D) characterization of brain tissues on cellular level is attractive for neurodegenerative studies as it can improve understanding of such diseases that cause a progressive deterioration as Alzheimer's or Parkinson's diseases. Grating-based X-ray phase-contrast micro tomography (PCμCT) is a non-destructive 3D imaging modality that allows simultaneous reconstruction of absorption, phase and scattering (dark-field) data [1], which is suitable for visualization of soft and hard tissues [2] with cellular resolution, and which can be implemented into a laboratory environment. The aim of the present study is to evaluate performance of the single-grating interferometry for a brain tissue investigation, using a human cerebellum block as an example.

METHODS: A human cerebellum extracted from a 73 year-old male was visualized *post mortem*. The tissue was formalin-fixed, dehydrated and paraffin-embedded. Cylindrical specimens were 4 mm in diameter and 23 mm in height. The imaging data was acquired using a single-grating setup at Diamond Manchester imaging beamline I13-2 (Diamond Light Source, Didcot, UK). The tomography was performed over 180º with a step of 0.15º, at a mean photon energy of 19 keV, using Ni grating with a periodicity of 10 μm and structure height of 10 μm, effective pixel size of 2.3 μm, at a grating-detector distance of 72 cm, corresponding to a 1st Talbot order.

RESULTS: As demonstrated in the selected slice in Fig. 1, PCμCT data reveals a variety of tissue types including *stratum granulosum* (1), *stratum moleculare* (2) and white matter (3), individual blood vessels and a diversity of cell types. These presumably include Purkinje cells (white arrow), granule cells in the *stratum granulosum*, and stellate cells in the *stratum moleculare*. The phase images reveal inner structures of the tissue with high contrast while the absorption data provides a complementary edge enhancement.

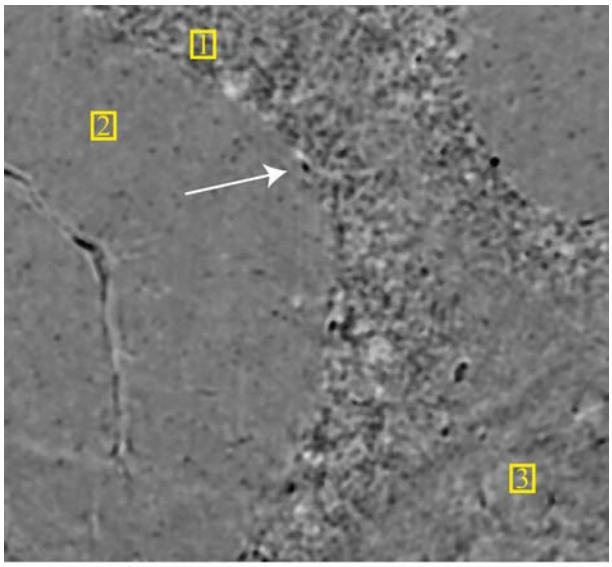

Fig. 1: Combined slice of the absorption- and phase-contrast data of a human cerebellum showing the variety of cell types. 1: stratum granulosum; 2: stratum moleculare; 3: white matter; white arrow: Purkinje cell.

DISCUSSION & CONCLUSIONS: PCμCT is well suited for 3D characterization of physically soft tissues as it provides a superb price-performance ratio between spatial resolution, density contrast, and required time. PCμCT bears the potential to become an important auxiliary modality in neurodegenerative disorders research.

REFERENCES: [1] F. Pfeiffer, J. Herzen, M. Willner, et al (2013) *Z. Med. Phys.* **23(3)**:176-185. [2] M. Holme, G. Schulz, H. Deyhle, et al (2014) *Nat. Protoc.* **9**:1401–15.

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