6th European Conference for Clinical Nanomedicine, June 23-26 2013, Basel, Switzerland

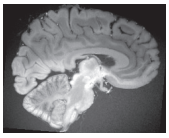
Abundance and orientation of myelin sheaths in parts of human brains

Georg Schulz[1], Hans Deyhle[1,2], Oliver Bunk[2], and Bert Müller[1]

[1]*Biomaterials Science Center, University of Basel, Switzerland*

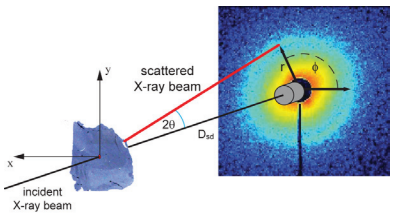
[2]*Swiss Light Source, Paul Scherrer Institut Villigen, Switzerland*

INTRODUCTION



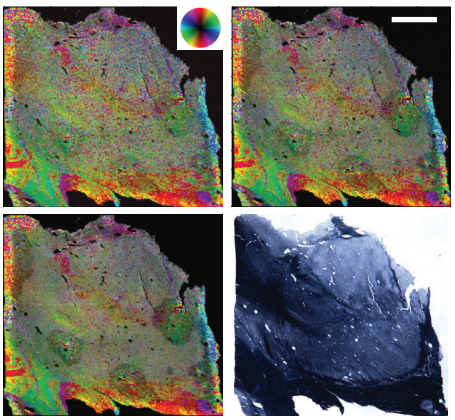
For human brain tissues histology is so far the gold standard for the differentiation of the structures on the sub-cellular level. Using small-angle X-ray scattering (SAXS), which is a reciprocal space technique with an inverse relationship between the size of the inspected particles and scattering angle, nanostructures within the human brain (e.g. myelin with a periodicity of 16.46 nm) can be detected [1]. But it is impossible to relate the results to established histology because of the lack of localization. Combination of SAXS with a spatial resolution of a few micrometers in real space (scanning SAXS at cSAXS beamline, SLS, PSI, Switzerland [2]) provides information on the abundance and orientation of the nanostructures present [3]. The result is a more detailed understanding of the nanoanatomy of human brain tissue.

SCANNING SAXS



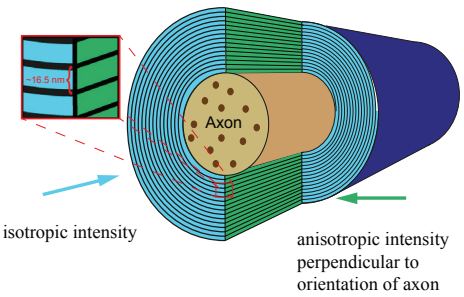
- cSAXS beamline (SLS, PSI)
- 11.2 keV for the section placed in polyimide sachet, 18.58 keV for slices mounted on conventional microscopy glass plates
- X-ray beam focused to 20 × 5 µm²
- scanned over the slice in 50 and 100 µm steps in the two directions perpendicular to the brain slice
- acquisition rate of 5 images per second
- scattering signal recorded using a PILATUS 2M detector placed in a distance of about 7.1 m (D_{sd})

MYELIN STAIN



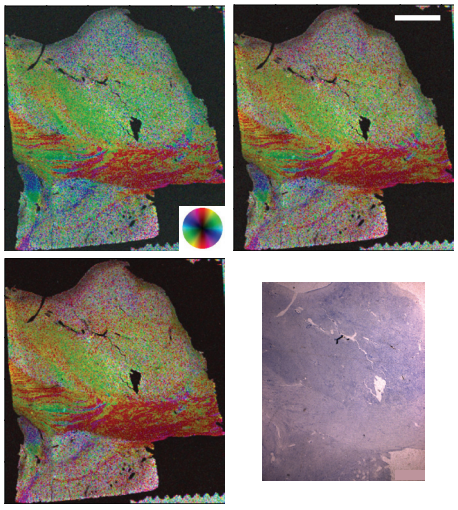
- orientation of nanostructures in the ranges of 40 to 50 nm, 50 to 60 nm and 60 to 70 nm of a myelin stained thalamus slice mounted on a microscopy glass plate according to color wheel
- brightness is associated with nanostructure abundance
- only a few smaller regions inside the thalamus show well defined orientation
- region outside the thalamus contains strongly oriented nanostructures
- length scale bar corresponds to 5 mm.

MYELIN SHEATHS

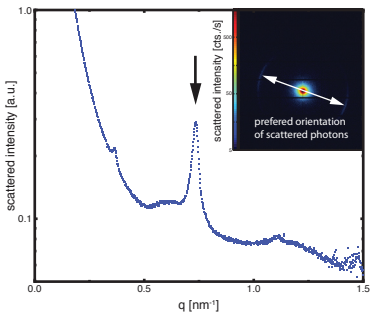


NISSL STAIN

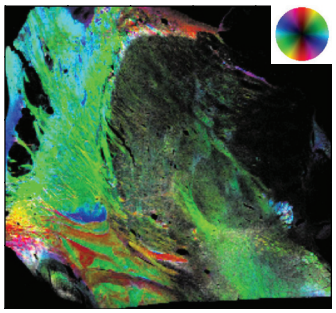
- processed scattering signals of a NISSL stained thalamus slice mounted on a microscopy glass plate in the ranges 70 to 80 nm, 102 to 110 nm and 131 to 145 nm from top left to bottom left
- first image shows no significant orientation inside the thalamus, but in the adjacent region
- in the next two ranges, well defined regions with orientations of nanostructures (green, pink) appear inside the thalamus
- length scale bar corresponds to 5 mm.



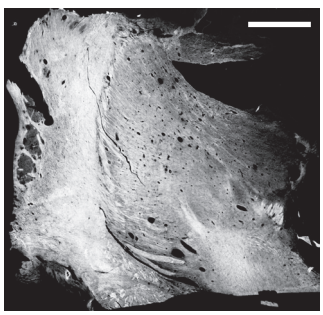
NO STAIN



- radial intensity profile exhibits four peaks
- first peak corresponds to a typical myelin periodicity of 16.5 nm
- third peak (arrow head) corresponding to 8.3 nm is the second diffraction order signal.



The figure above shows the signal from an unstained cryosectioned slice, placed in a polyimide sachett, in the range of 8 to 9 nm. The orientation of the nanostructure is according to the color wheel. For comparison, the figure below shows the same slice after the scanning SAXS experiment and after myelin staining using black gold. The length scale bar corresponds to 5 mm.



CONCLUSION AND ACKNOWLEDGEMENT

Scanning SAXS is a powerful imaging technique which allows uncovering the nanostructure of human brain tissue. The method bridges the gap between the real space optical techniques with micrometer resolution and large field of view and the reciprocal space scattering / diffraction techniques with nanometer resolution for average structures, but without imaging capabilities, i.e., spatial resolution across the specimen. In the future scanning SAXS and SAXS tomography will play a dominant role in the further development of nanomedicine and related fields. The valuable contribution of M. Imholz, University Basel and A. Morel, University Hospital Zurich, especially during specimen preparation, are gratefully acknowledged. The project was partially funded by Swiss National Science Foundation (CR23I2_125406).

[1] M. De Felici, et al. (2008) *Physics in Medicine and Biology* ***53****:5675-5688.*
[2] O. Bunk, et al. (2009) *New Journal of Physics* ***11****:123016.*
[3] B. Müller, et al. (2010) *European Journal of Nanomedicine* ***3****:30-33.*