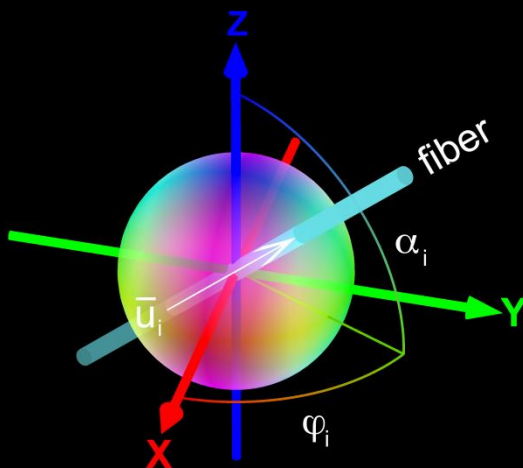


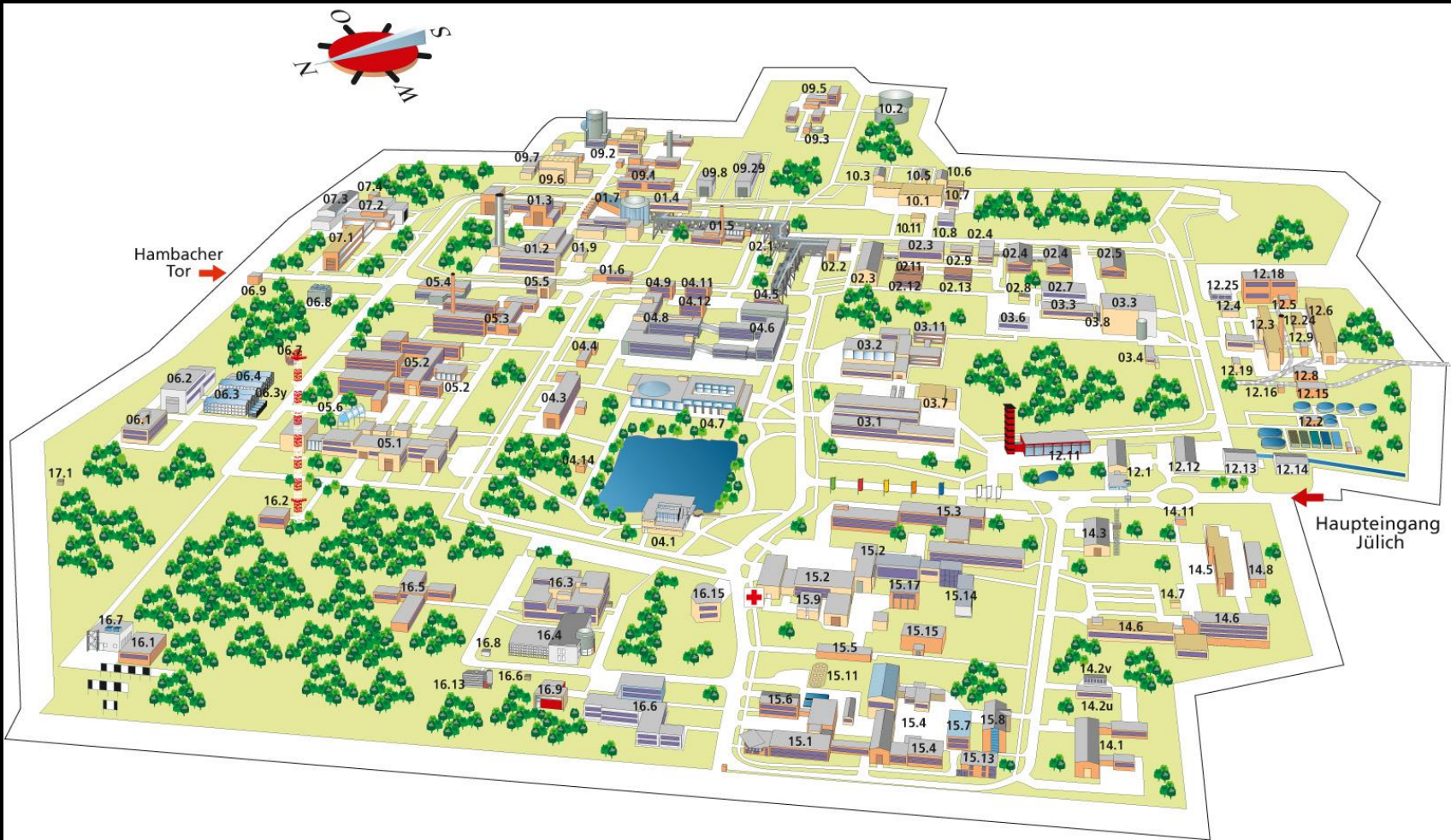
Investigation of histological brain sections at different scales with polarized light

Hendrik Wiese

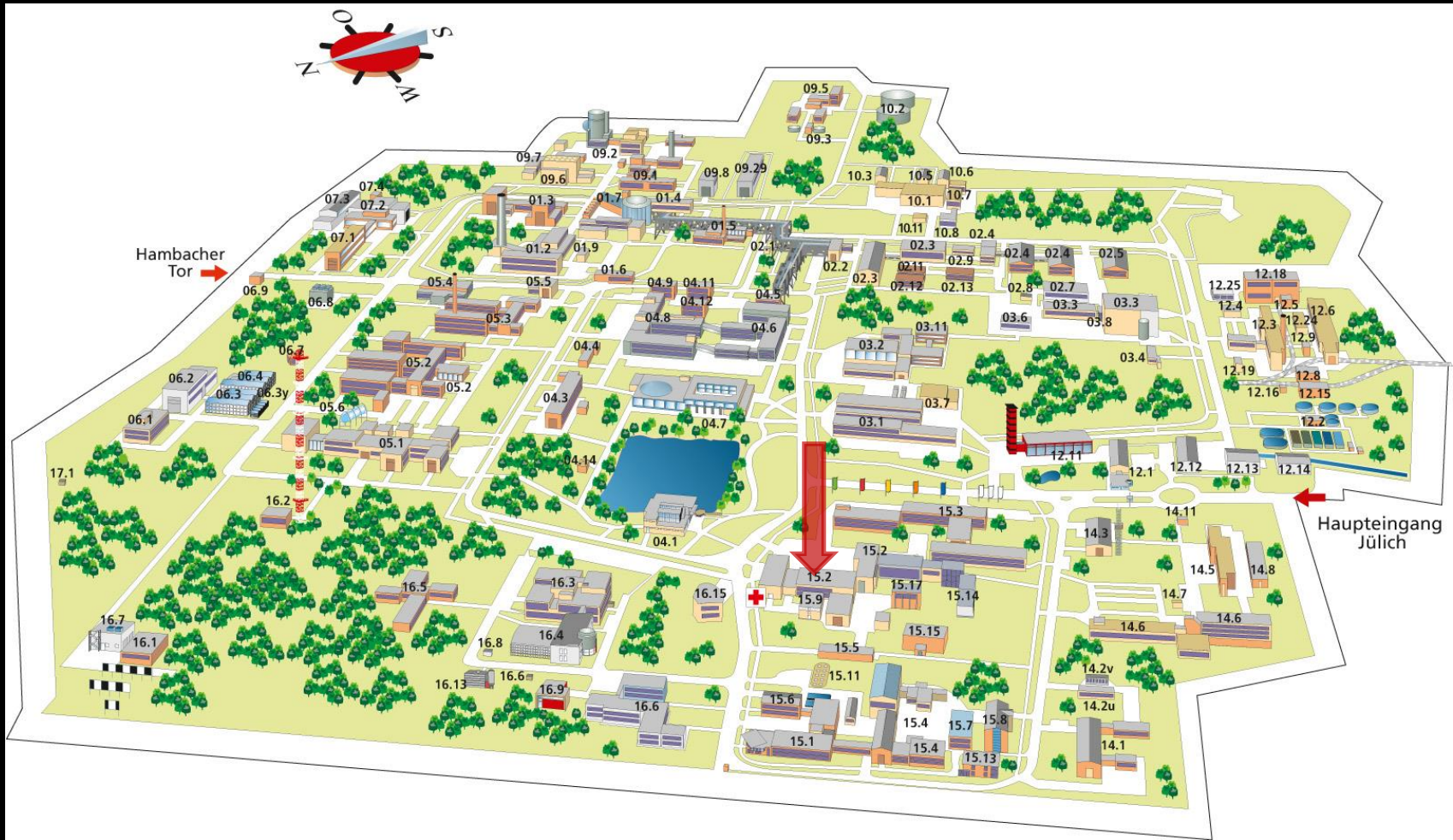
25.3.2014



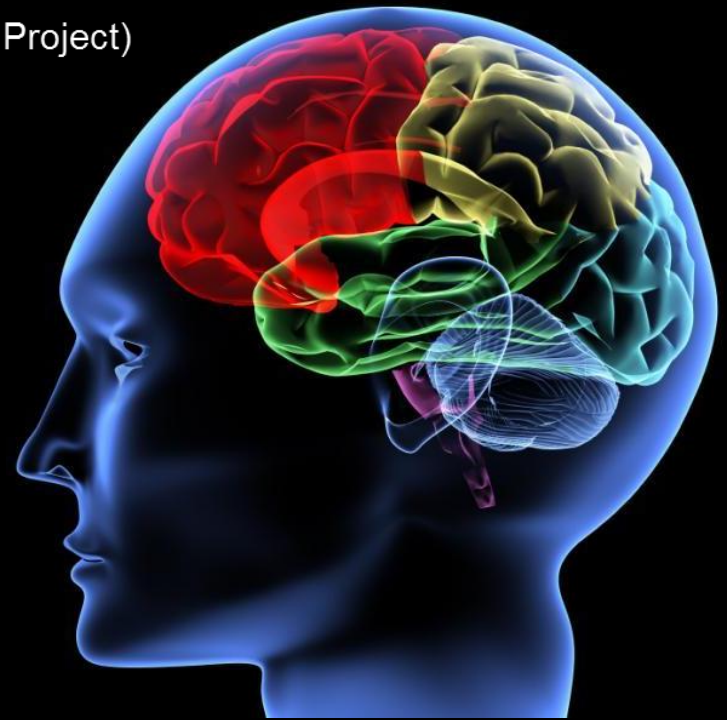
The Research Center Jülich and the INM

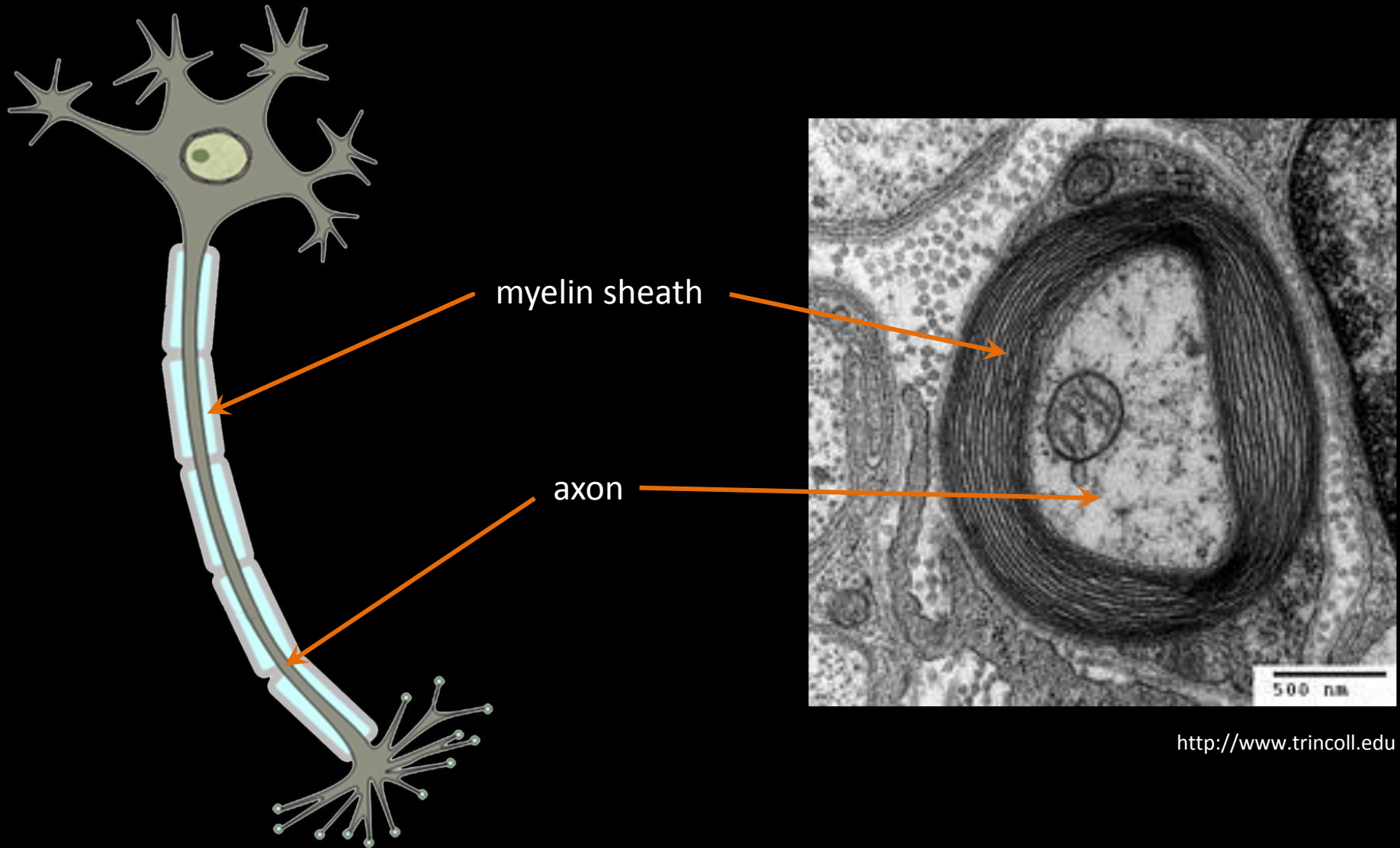


The Research Center Jülich and the INM

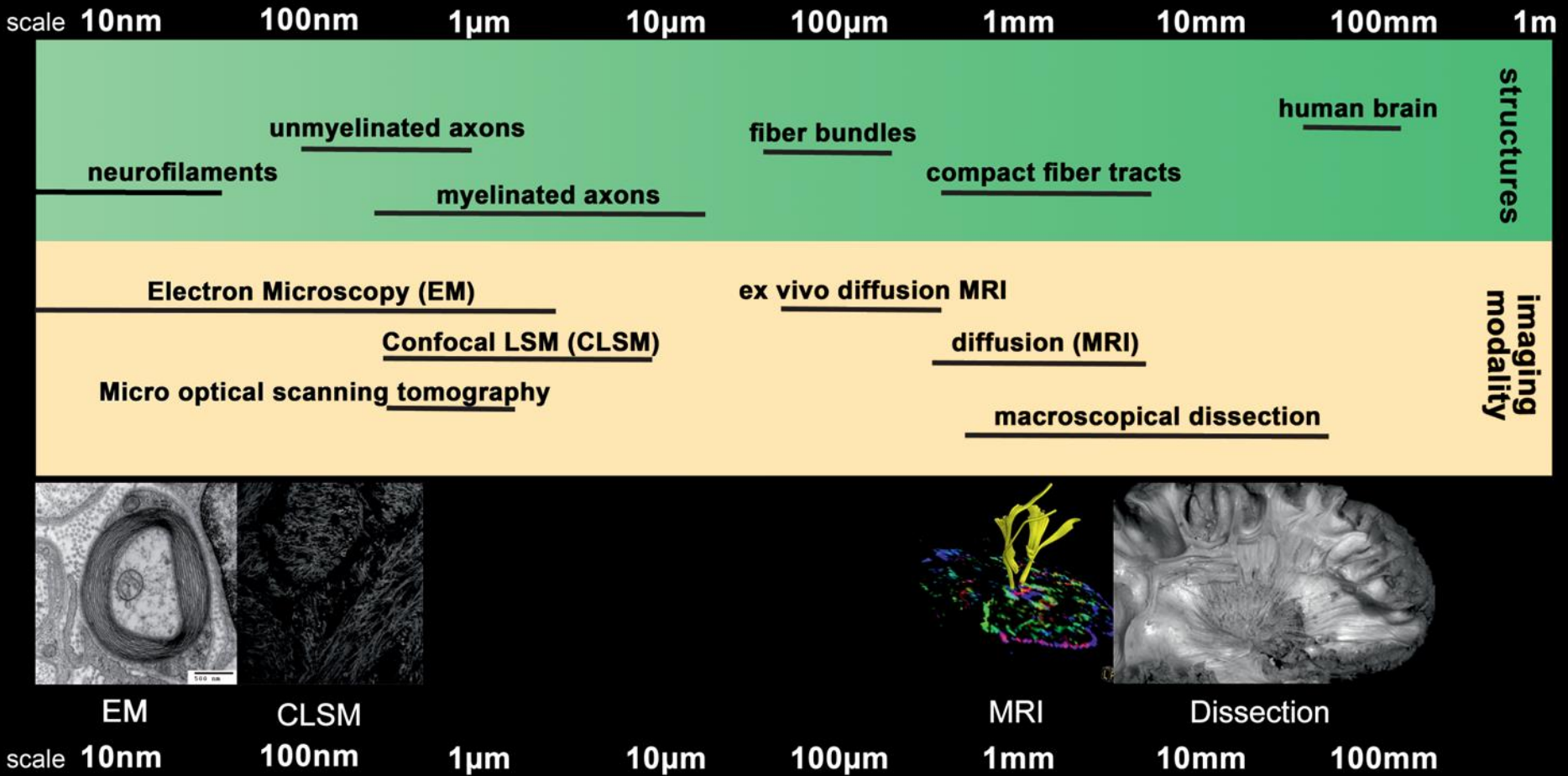


„Understanding the human brain is one of the greatest challenges facing 21st century science.“ (Human Brain Project)

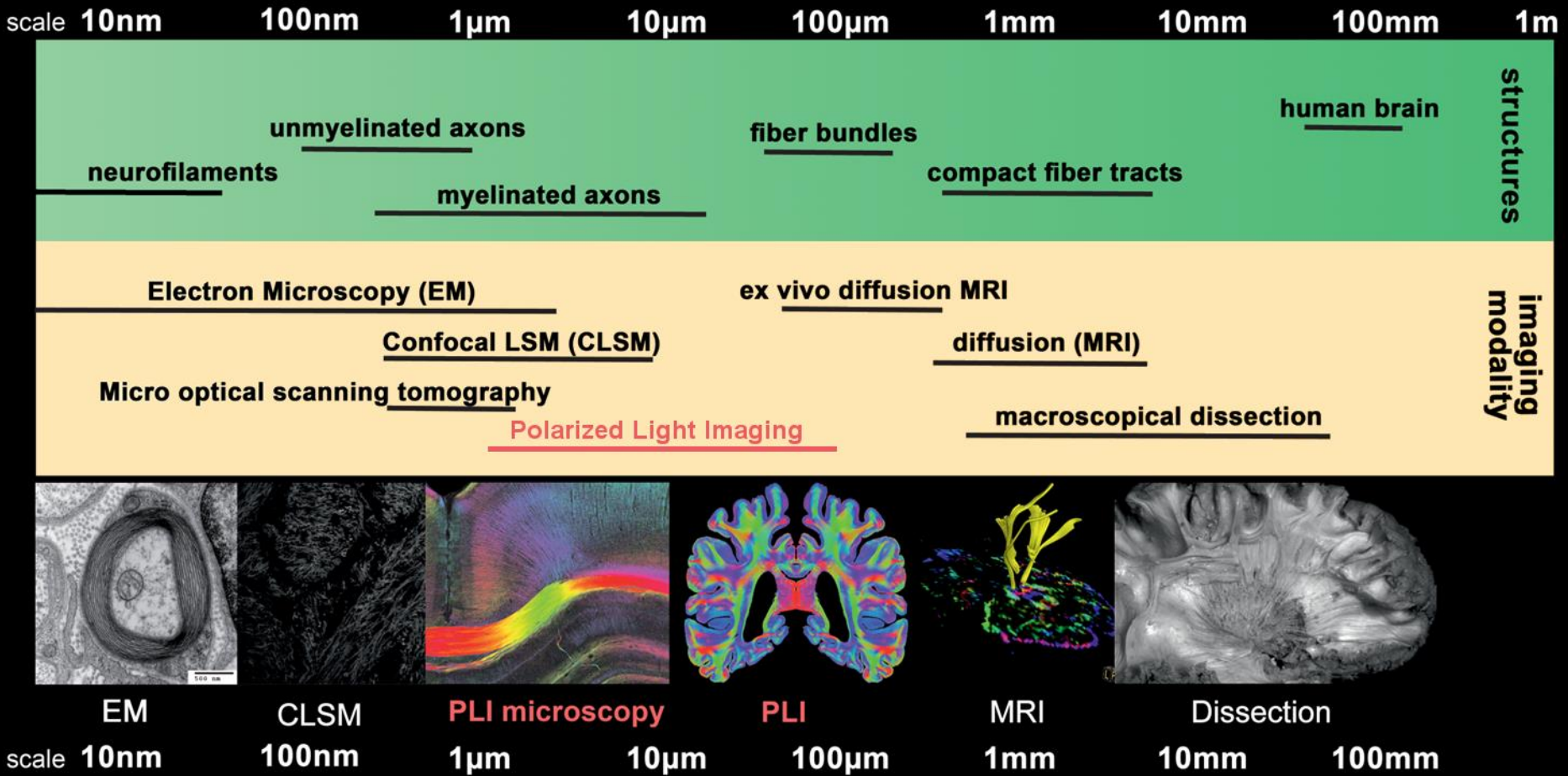


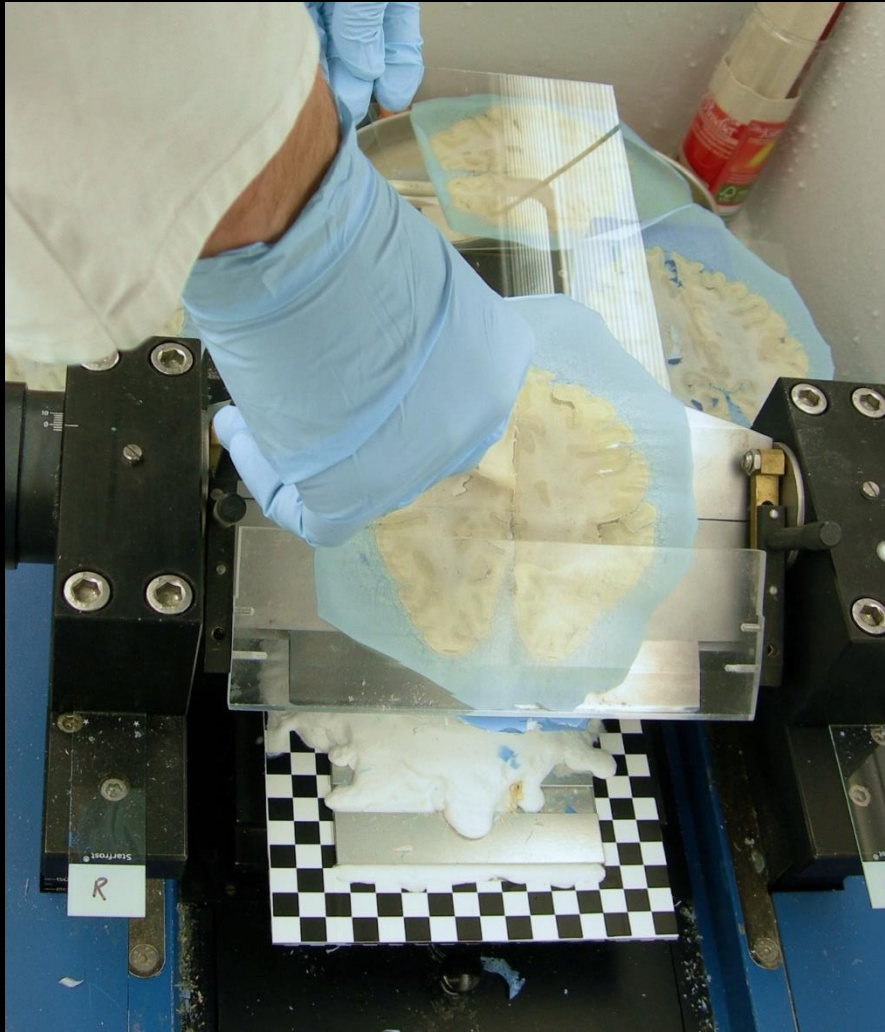


Neuroimaging Techniques

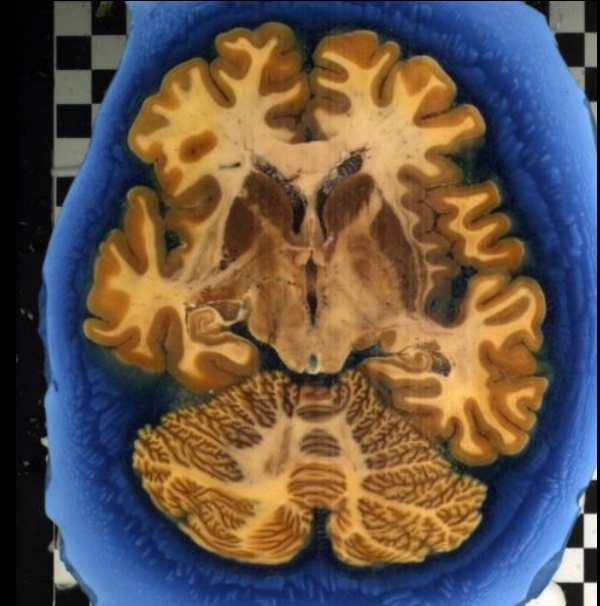


Neuroimaging Techniques

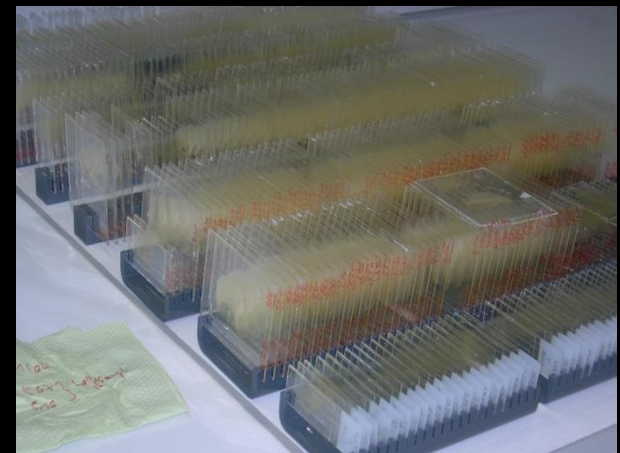




whole brain fixation in 4% formalin (for at least 6 months)
sectioning with cryostat microtome (70 μm thickness)

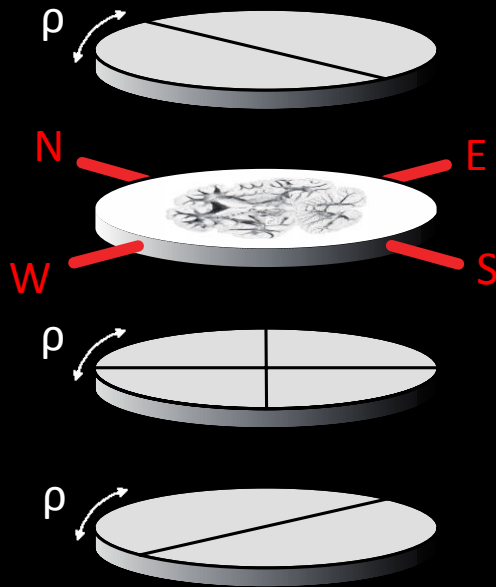


blockface imaging



2500 sections

Large-area Polarimeter



camera

linear polarizer

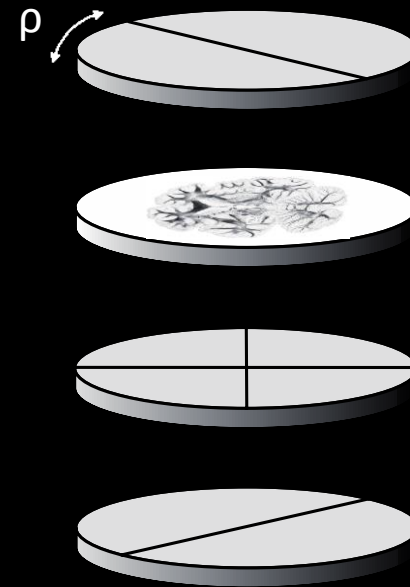
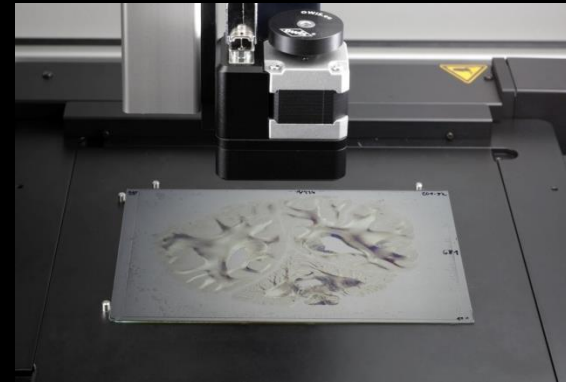
object stage

quarter-wave retarder

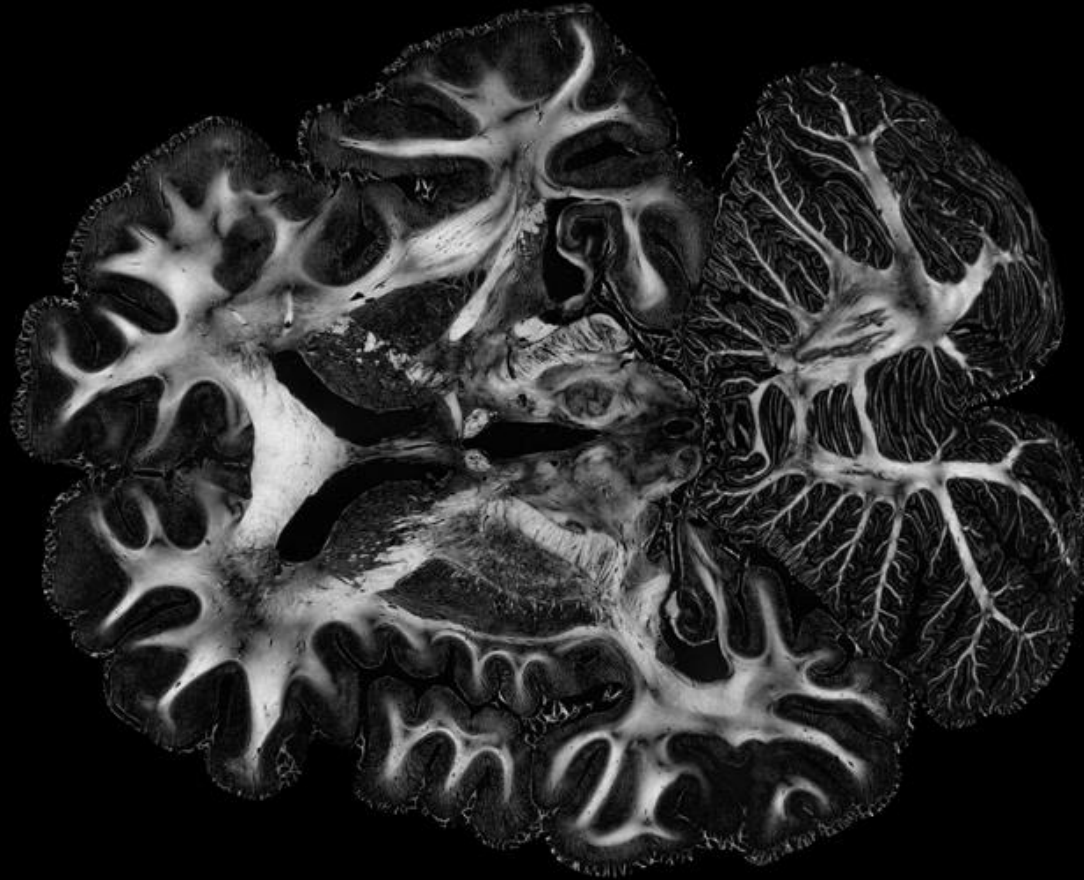
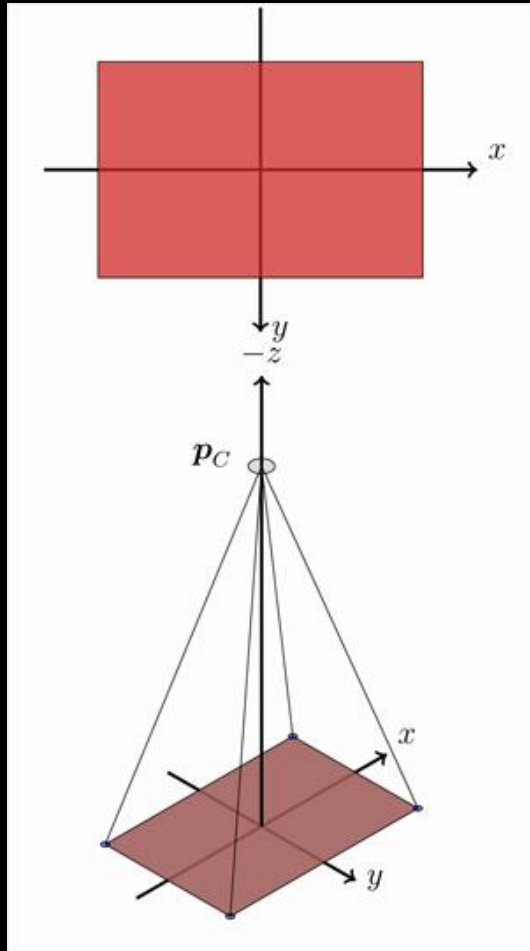
linear polarizer

light source

Polarizing Microscope



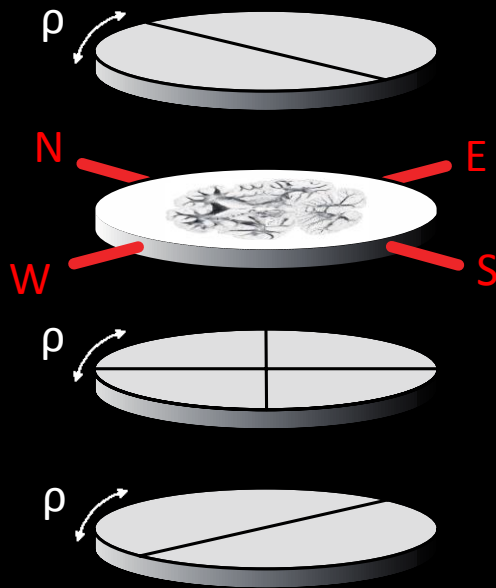
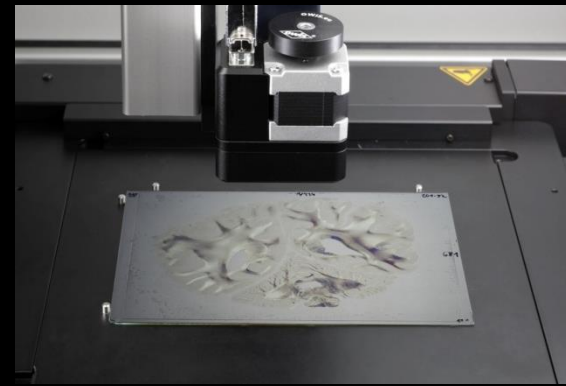
Microscope build by Taorad
<http://www.taorad.com/>



Large-area Polarimeter



Polarizing Microscope



camera

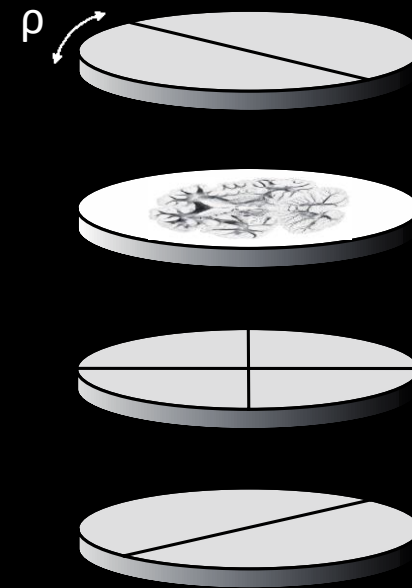
linear polarizer

object stage

quarter-wave retarder

linear polarizer

light source



Microscope build by Taorad
<http://www.taorad.com/>

Large-area Polarimeter



one-shot image

size: 2800×2080 pixel

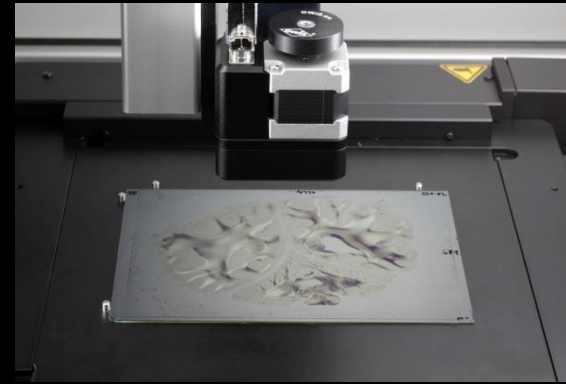
pixel size: 64 μm × 64 μm

file size: 3 GB

15 min scan time / section

tilting object stage

Polarizing Microscope



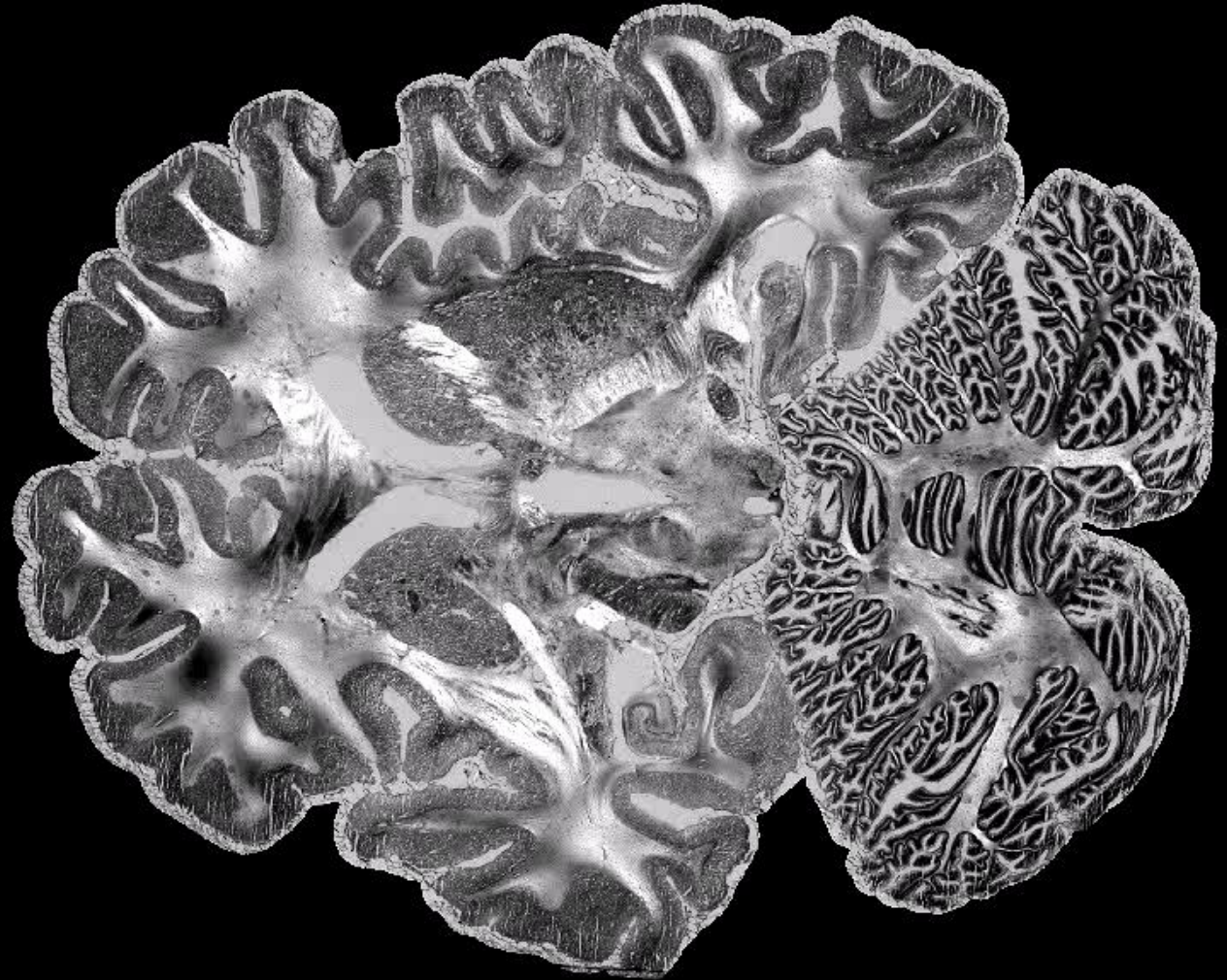
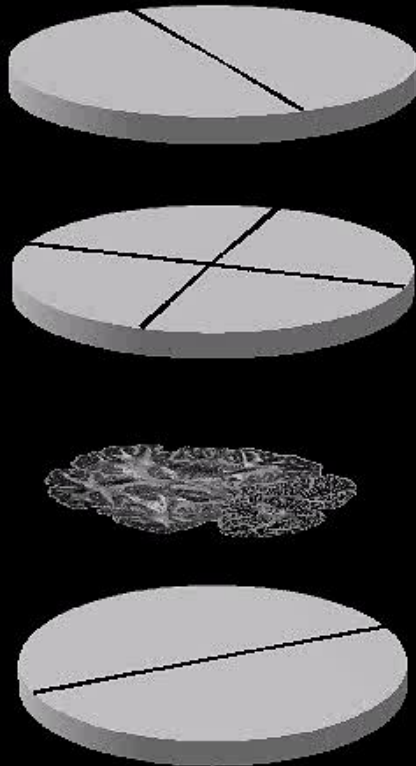
tiled image

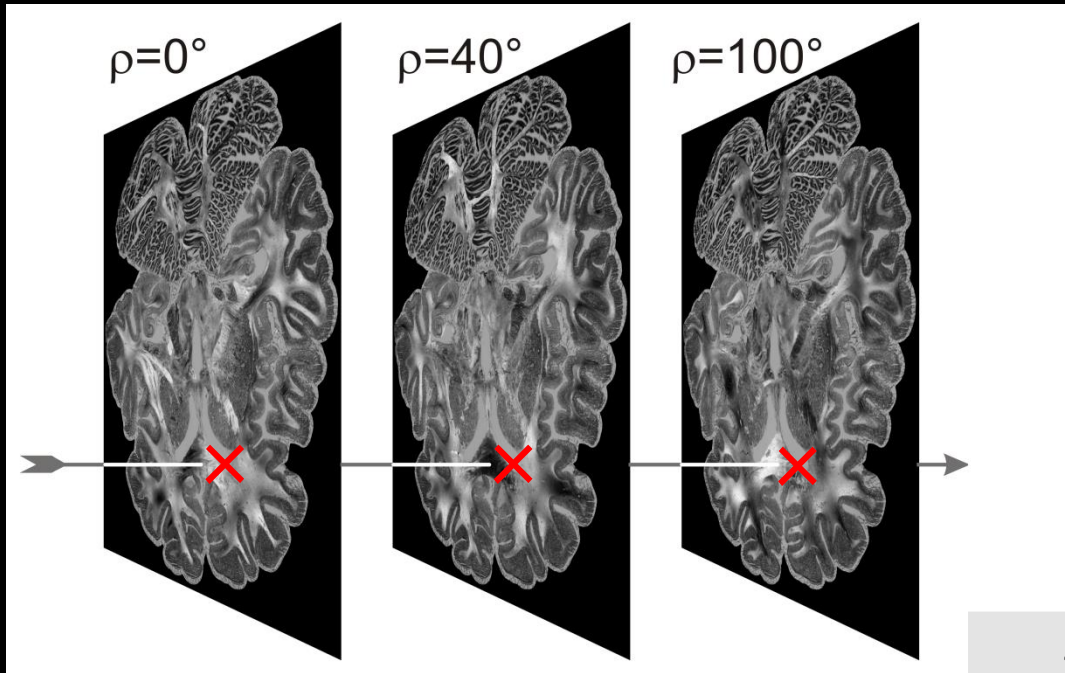
size: 100.000 × 100.000 pixel

pixel size: 1.3 μm × 1.3 μm

file size: 750 GB

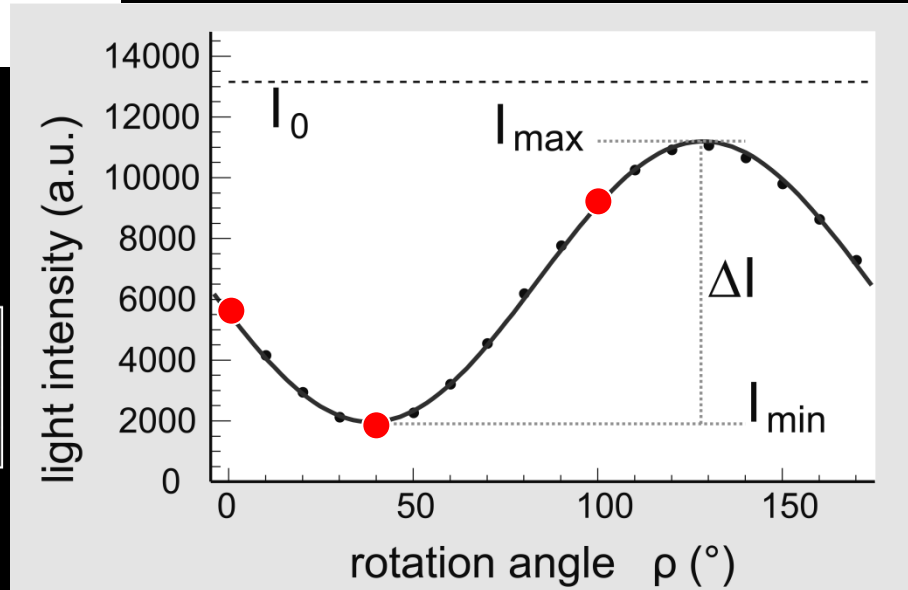
12 hrs scan time / large section

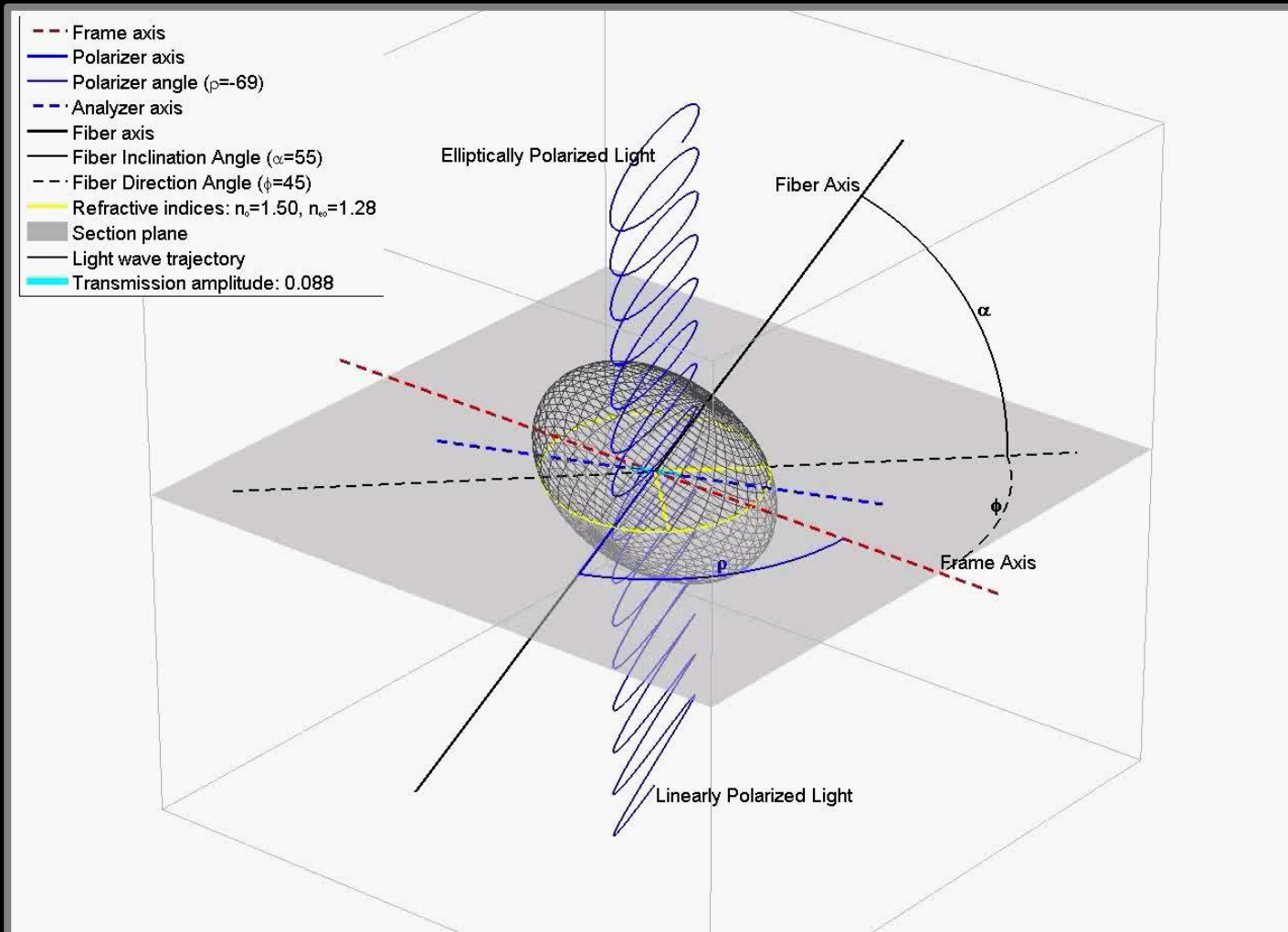


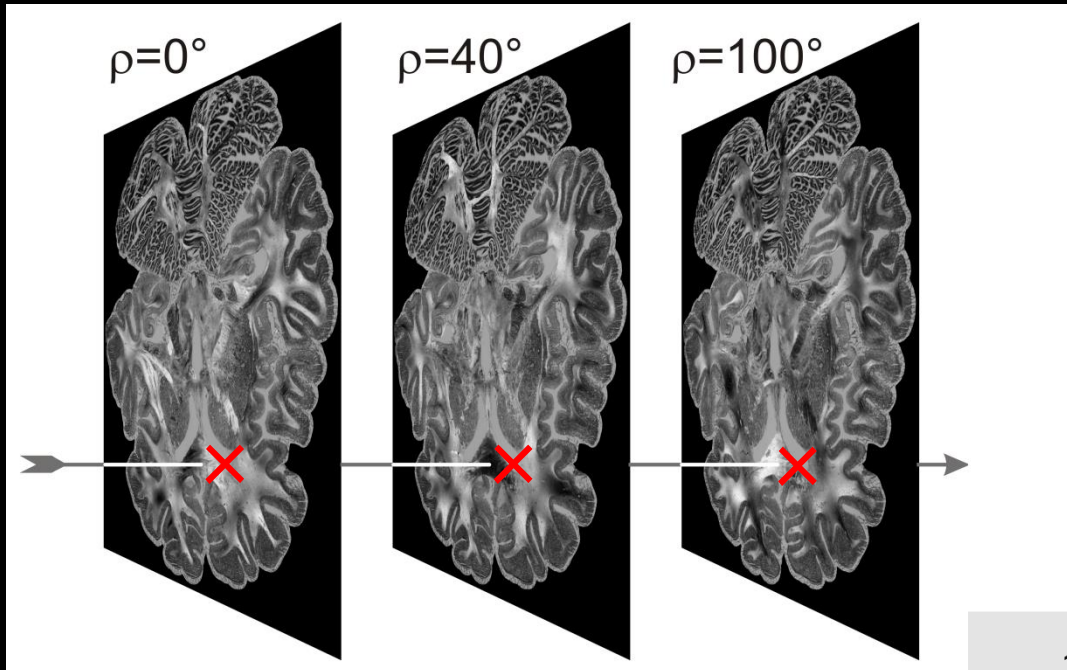


$$I = \frac{I_0}{2} \left[1 + \sin \left(2\rho - 2\varphi - \frac{\pi}{2} \right) \cdot \sin \delta_{d,\lambda,\Delta n,\alpha} \right]$$

Jones (1941) J. Opt. Soc. Am. 31



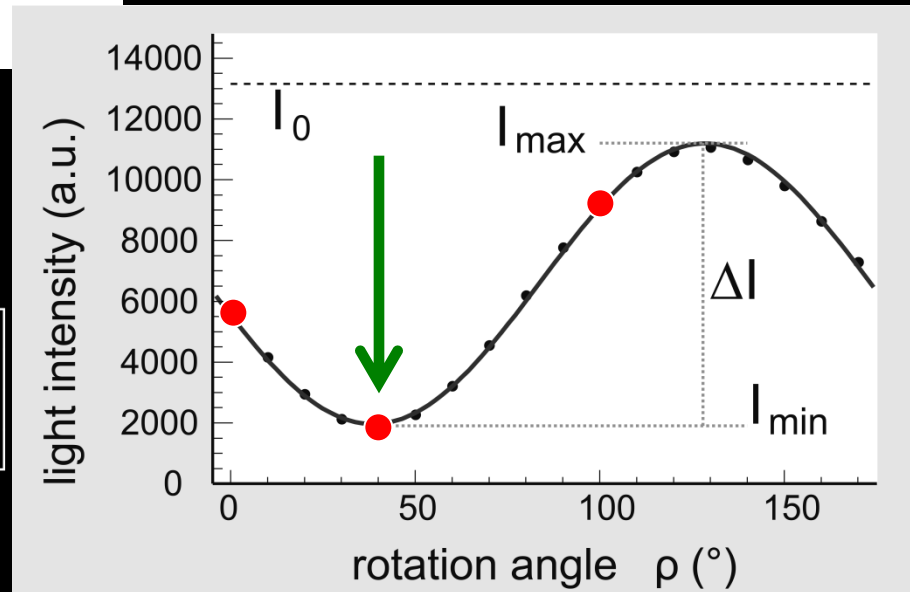


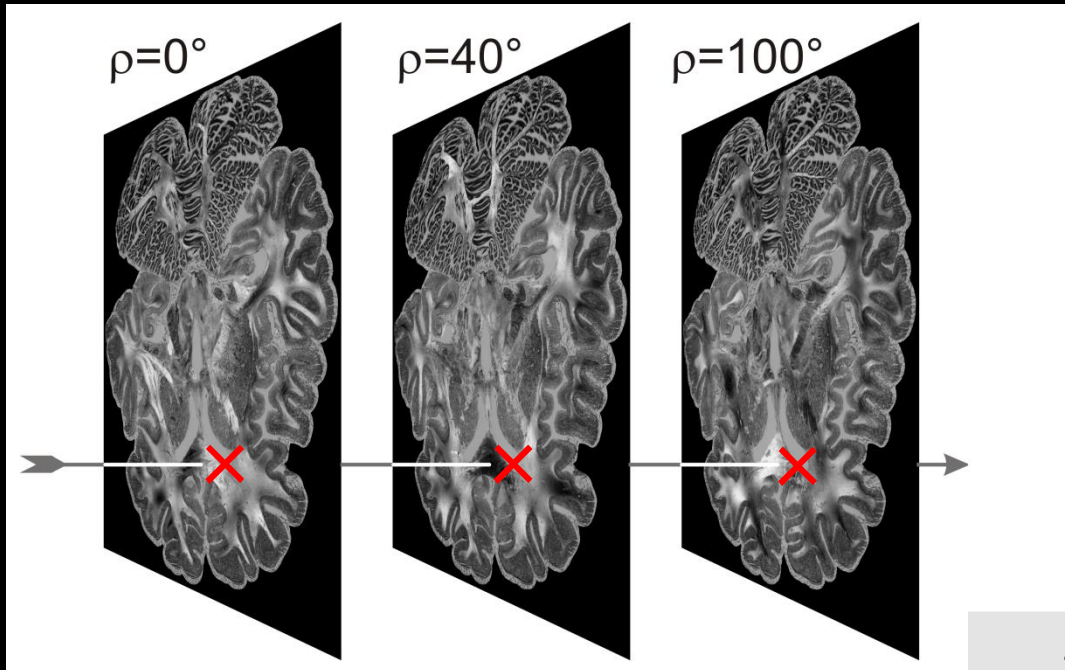


$$I = \frac{I_0}{2} \left[1 + \sin \left(2\rho - 2\varphi - \frac{\pi}{2} \right) \cdot \sin \delta_{d,\lambda,\Delta n,\alpha} \right]$$

Direction

Jones (1941) J. Opt. Soc. Am. 31

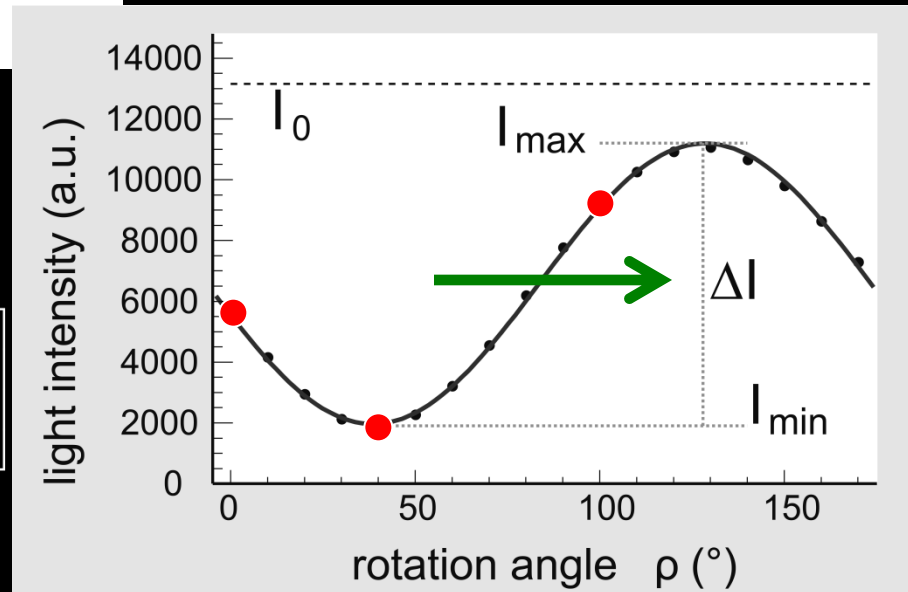


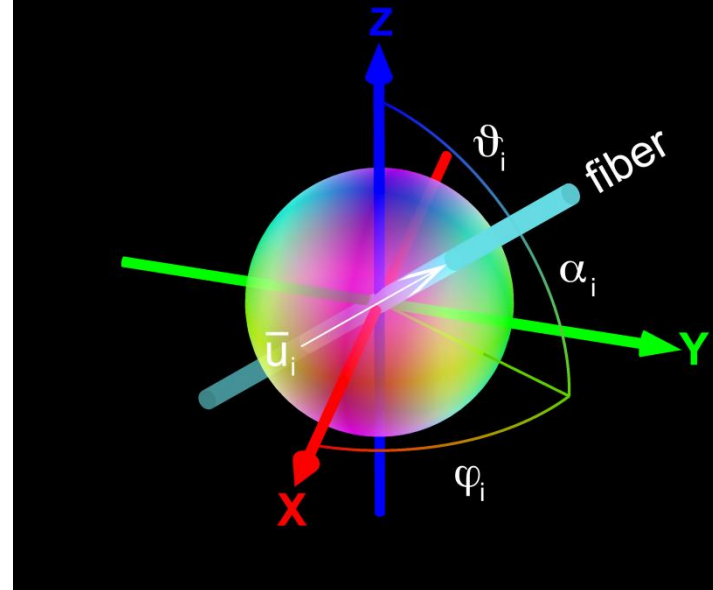
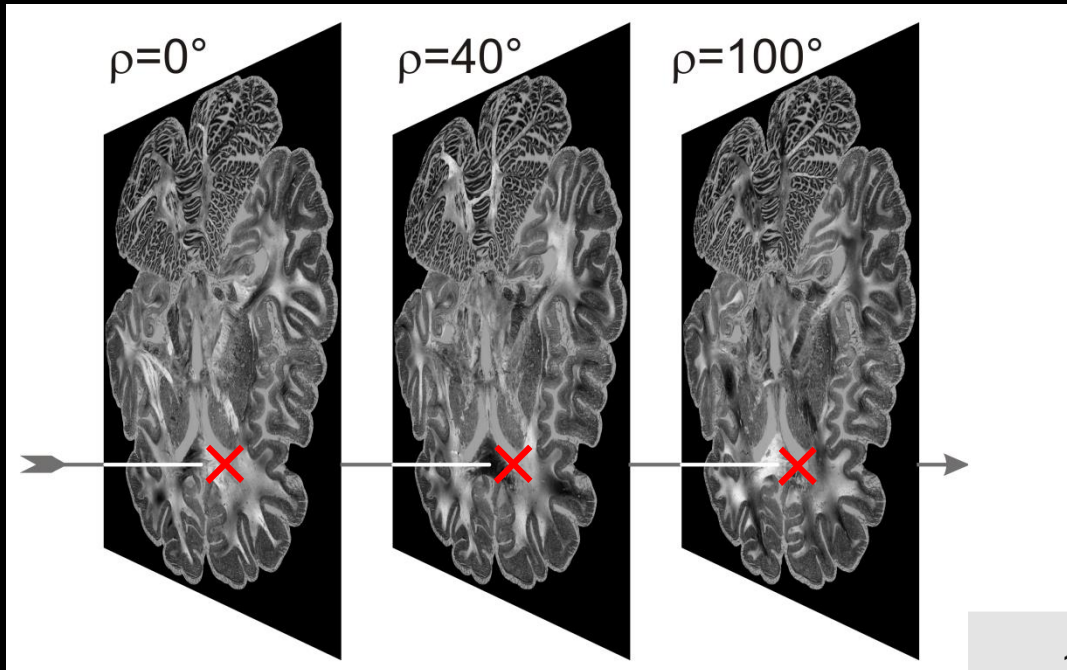


$$I = \frac{I_0}{2} \left[1 + \sin \left(2\rho - 2\varphi - \frac{\pi}{2} \right) \cdot \sin \delta_{d,\lambda,\Delta n,\alpha} \right]$$

Inclination

Jones (1941) J. Opt. Soc. Am. 31

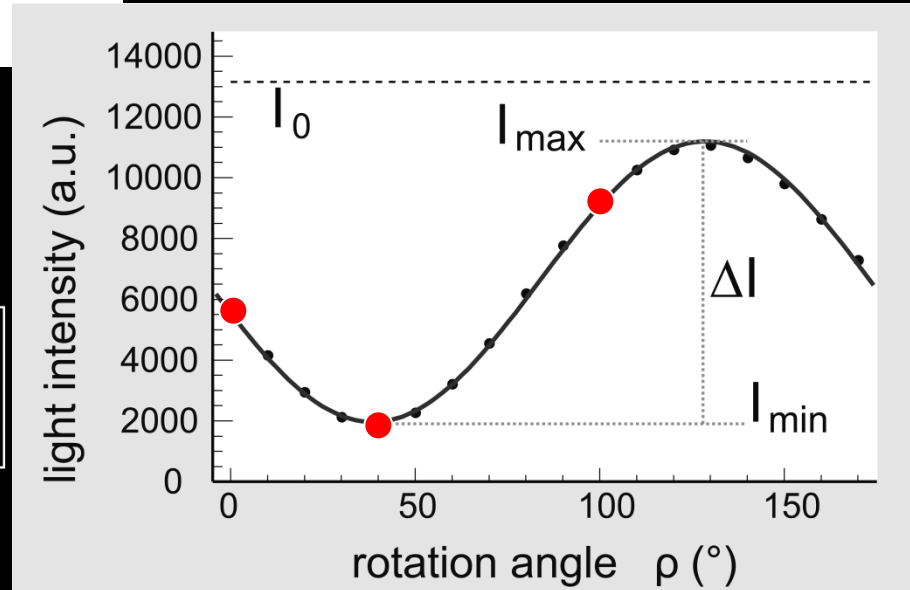




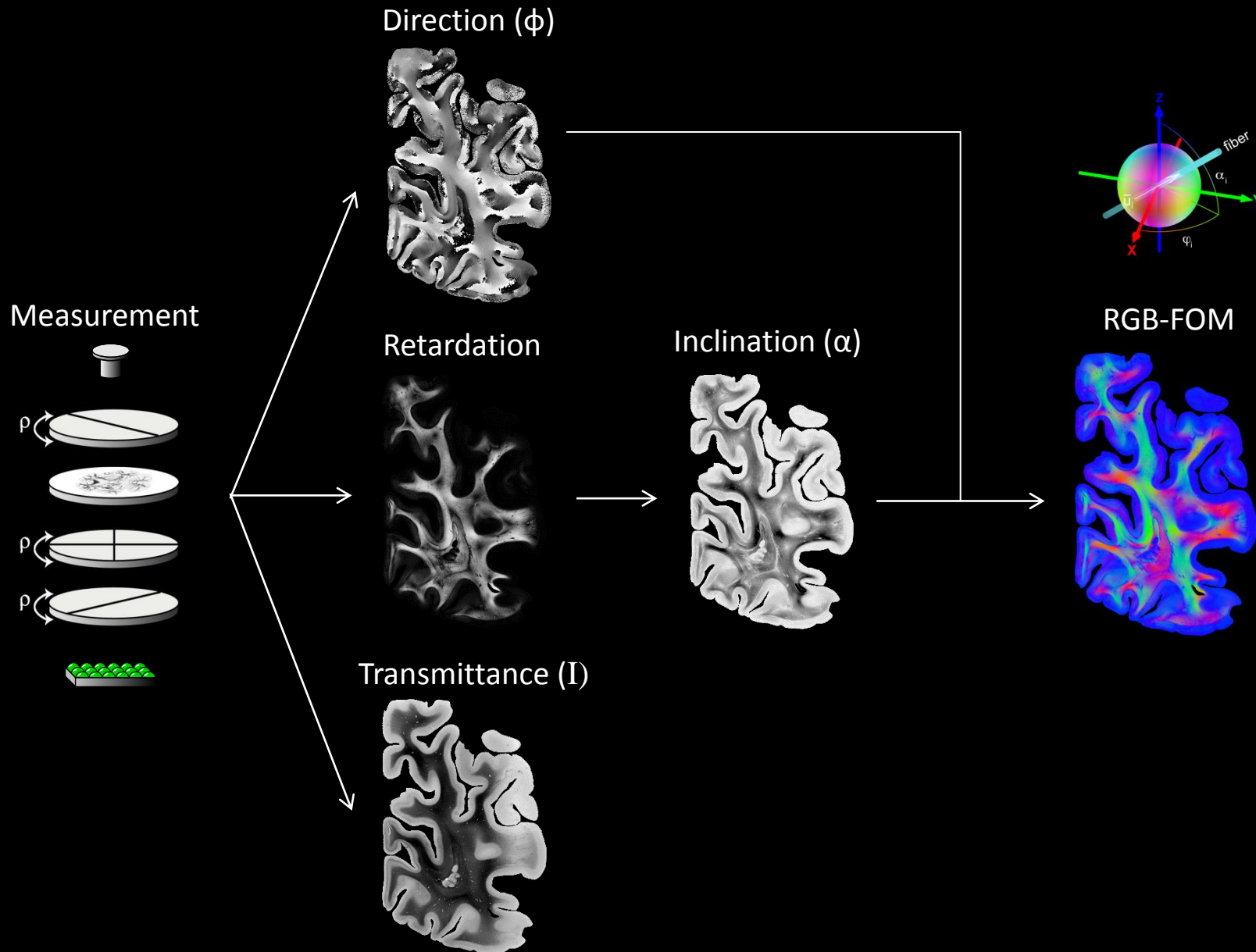
Direction φ	Inclination α
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$$I = \frac{I_0}{2} \left[1 + \sin \left(2\rho - 2\varphi - \frac{\pi}{2} \right) \cdot \sin \delta_{d,\lambda,\Delta n,\alpha} \right]$$

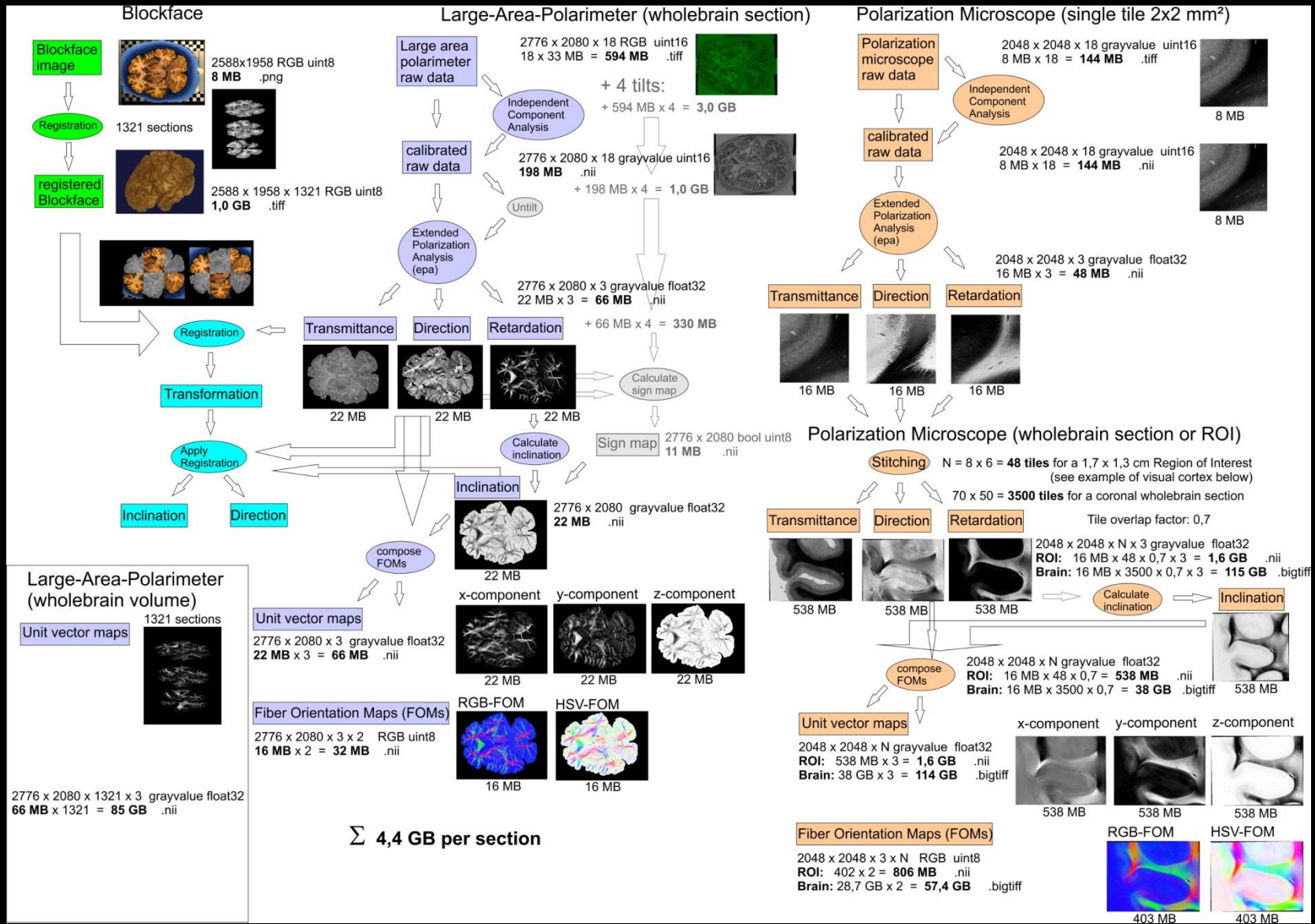
Jones (1941) J. Opt. Soc. Am. 31



Workflow (simple)



Workflow (real)



Data for a slice at microscopic resolution: 750 GB



Data for a slice at microscopic resolution: 750 GB x 2500 sections

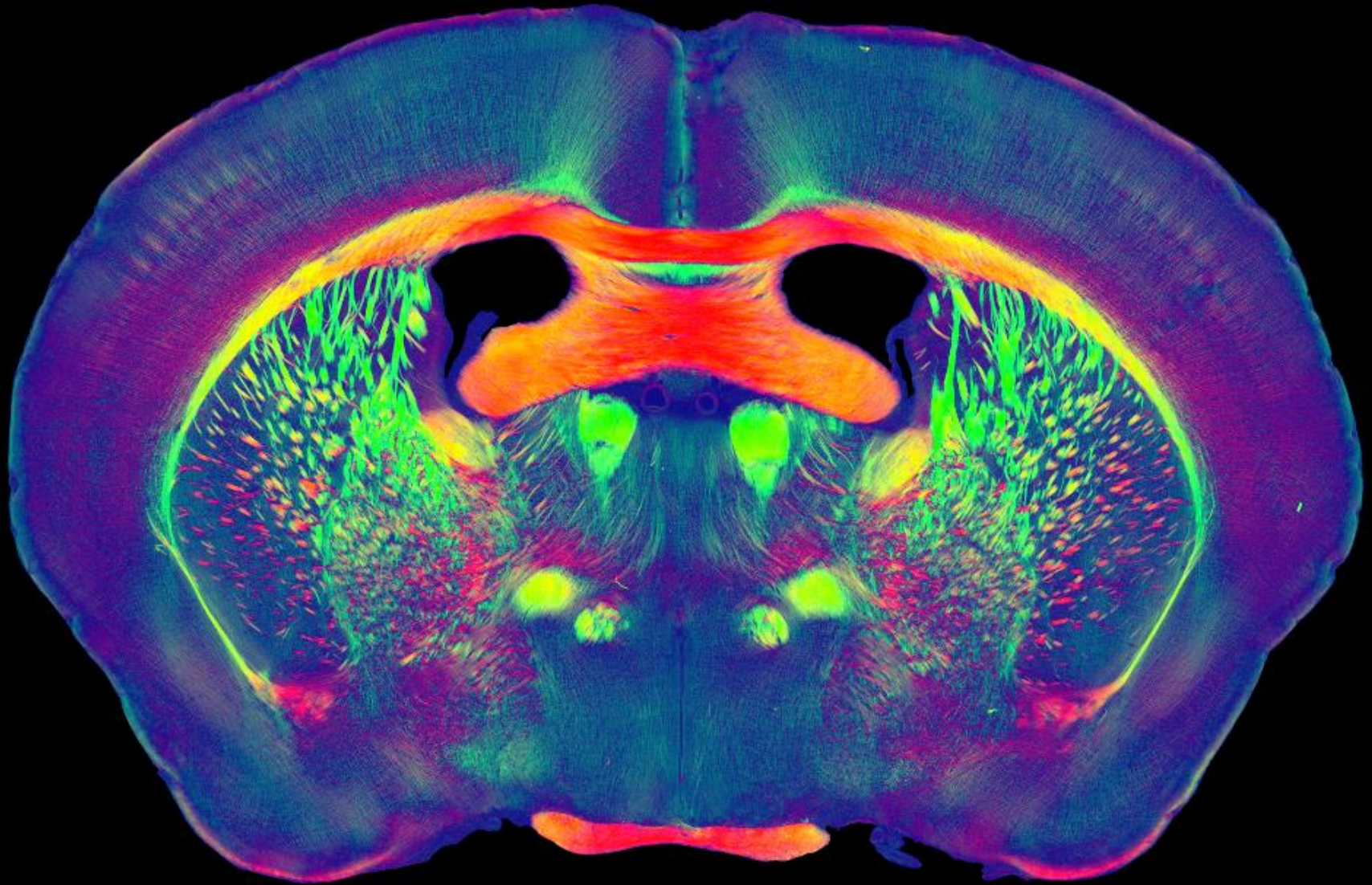


Data for a slice at microscopic resolution: 750 GB x 2500 sections

Need for suitable file storage system, data formats and visualization software

Need for high performance computing software for analysis and image registration





Thank You for Your Attention!

Institute of Neuroscience and Medicine (INM-1)



Markus Axer
David Gräbel
Anh-Minh Huynh
Marcel Huysegoms
Tim Hütz
Stefan Köhnen
Miriam Menzel
Julia Reckfort
Philipp Schlömer
Martin Schober
Guiseppe Tabbi

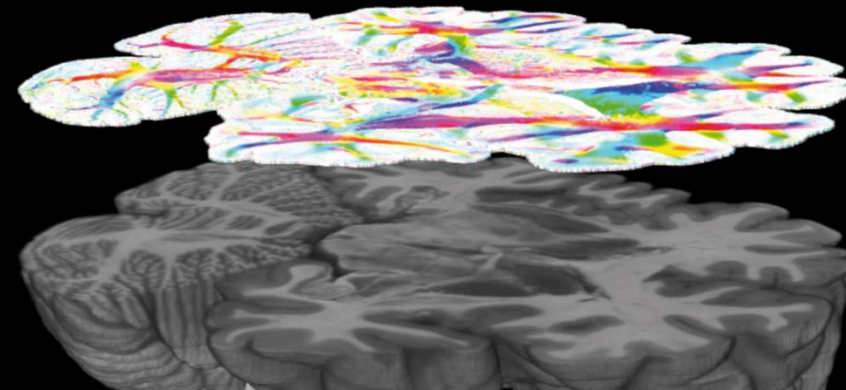
Jülich Supercomputing Center (JSC)

Oliver Bücker
Sven Strohmer
Anna Westhoff
Thomas Lippert

Contact:

h.wiese@fz-juelich.de
m.axer@fz-juelich.de

Further Reading:

- 
- [1] Axer et al., „A novel approach to the human connectome: Ultra-high resolution mapping of fiber tracts in the brain“, NeuroImage 54 (2011)
- [2] Axer et al., „High-resolution fiber tract reconstruction in the human brain by means of three-dimensional polarized light imaging“, Frontiers in Neuroinformatics 5(34) (2011).