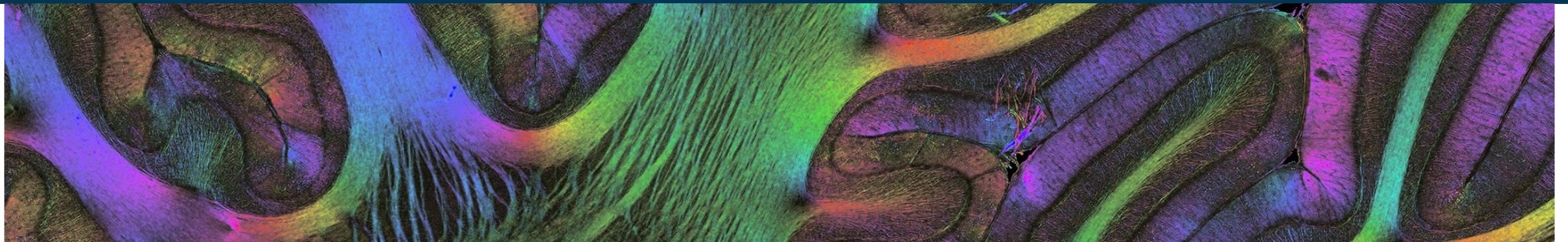




Markus Axer
Dennis Scheidt
Bastian Jaeger

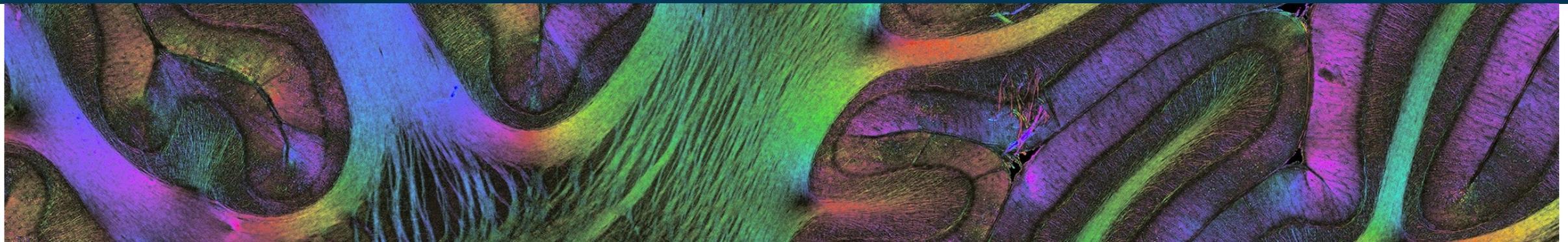
Gehirn und Mikroskopie

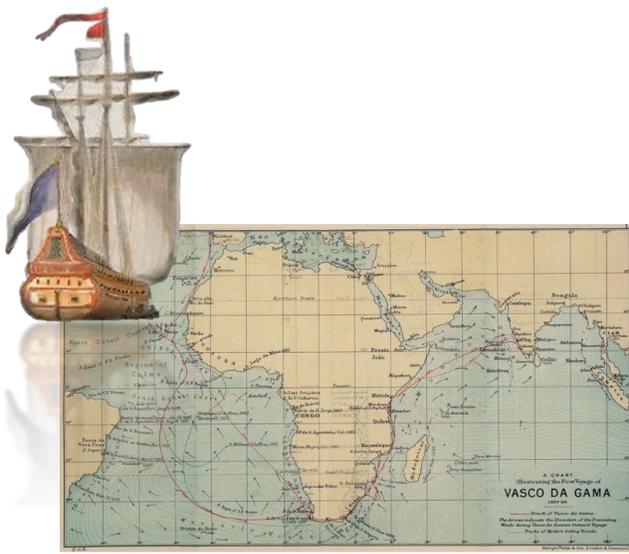




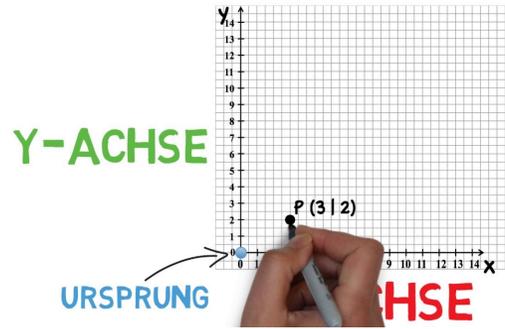
Markus Axer
Dennis Scheidt
Bastian Jaeger

Google Brain: Ein Atlas fürs Gehirn

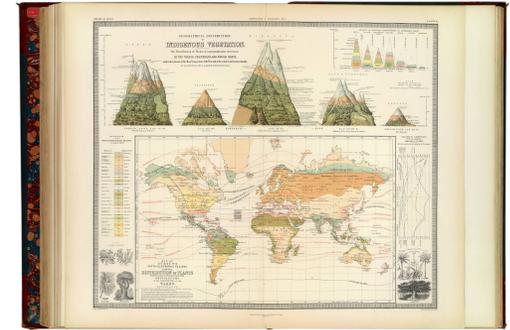




Karten



Koordinatensystem



regionale Eigenschaften

Google Brain: Ein Atlas fürs Gehirn

Wir benötigen ein geeignetes Koordinatensystem und die Eigenschaften und Namen aller Regionen aus verschiedenen „Flughöhen“ (Skalen).

Markus Axer
Dennis Scheidt
Bastian Jaeger

Google Brain: Ein Atlas fürs Gehirn

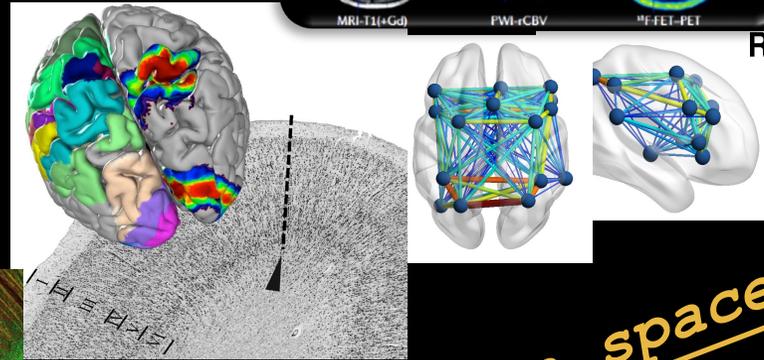
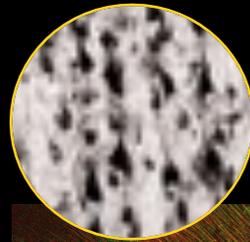
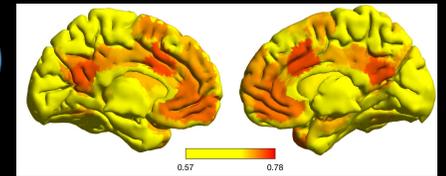
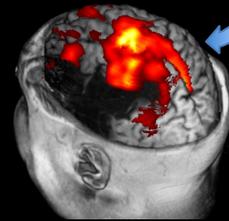
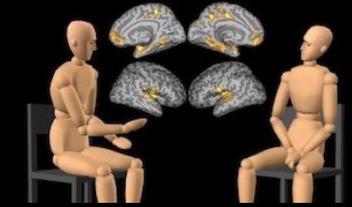
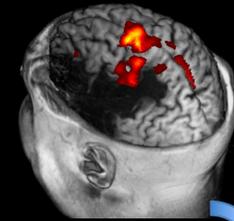
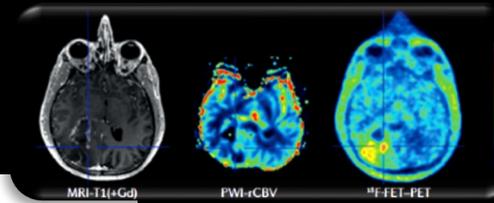
Wir benötigen ein geeignetes Koordinatensystem und die Eigenschaften und Namen aller Regionen aus verschiedenen „Flughöhen“ (Skalen).



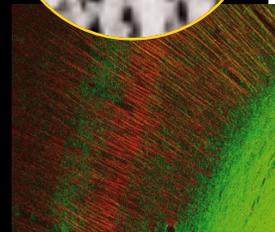
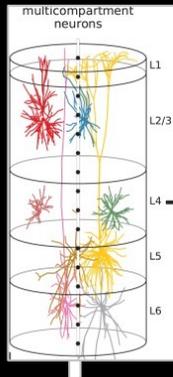
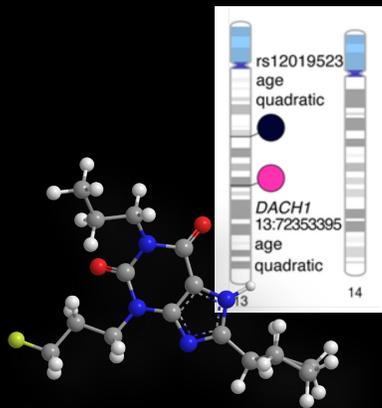
Neurowissenschaften am Forschungszentrum Jülich



Big Data Analytics,
Deep Learning,
Simulation &
Supercomputing



Different scales in space and time



MRI, PET, EEG

Scattering

Optical imaging

Receptor autoradiography

High-throughput Microscopy

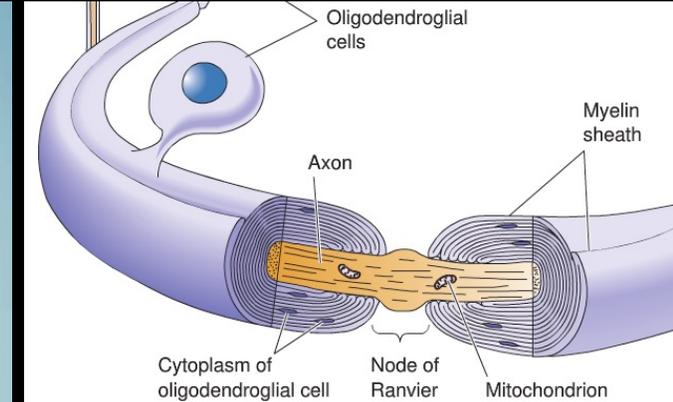
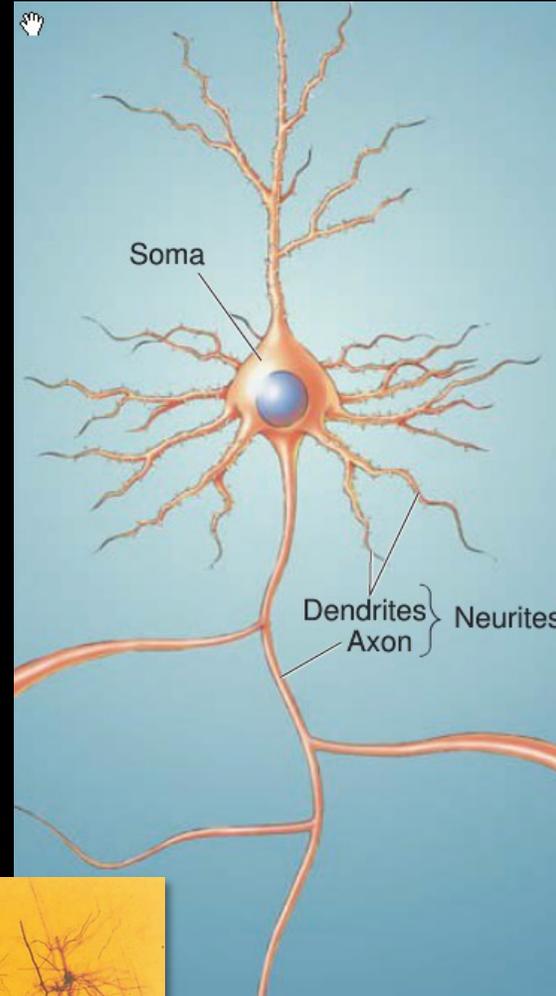
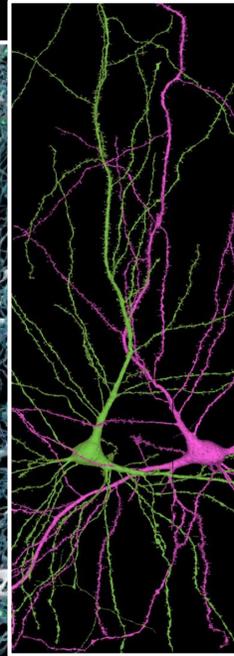
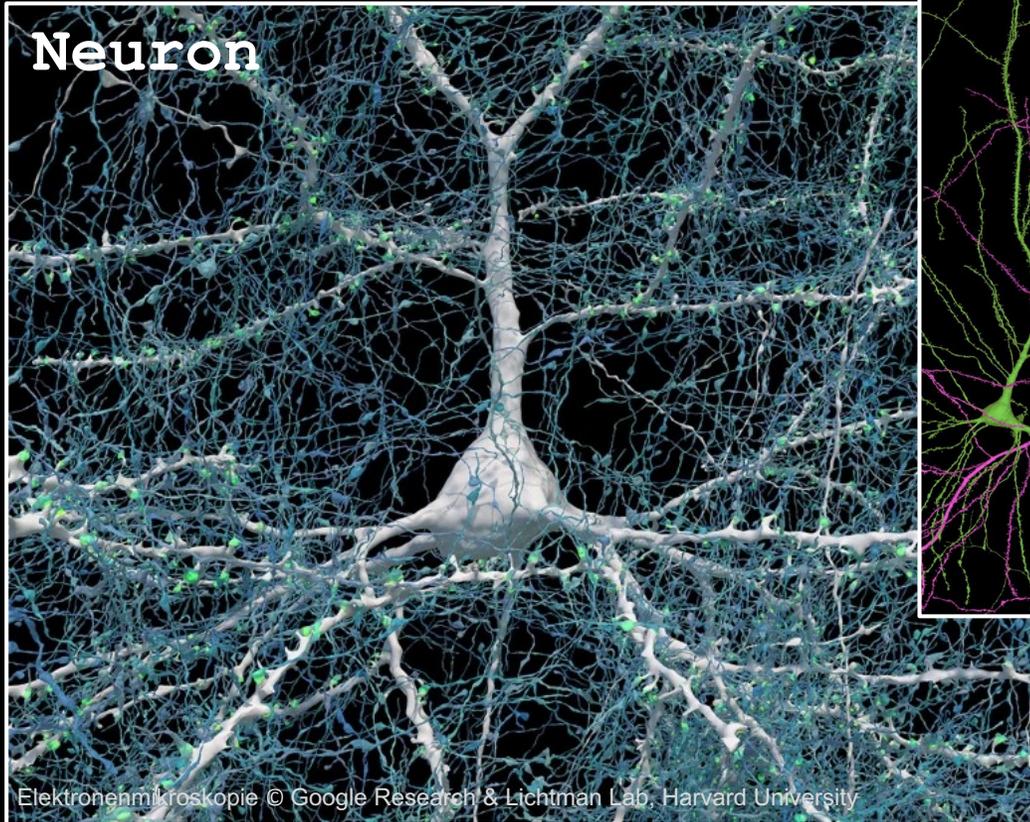
Structural biology

Cognitive neuroscience

Genome engineering



Viele Herausforderungen...



Axon + Markscheide = Faser

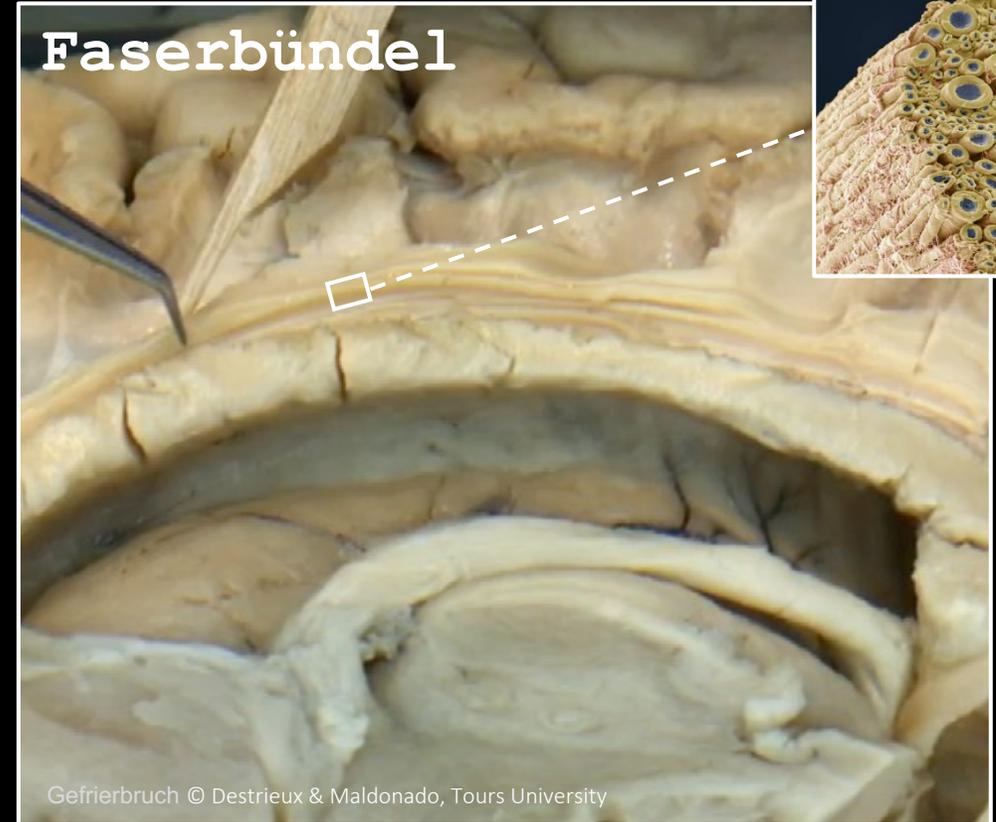
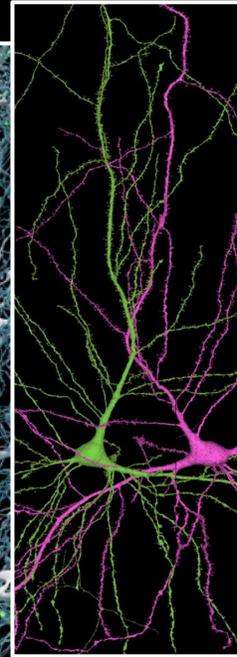
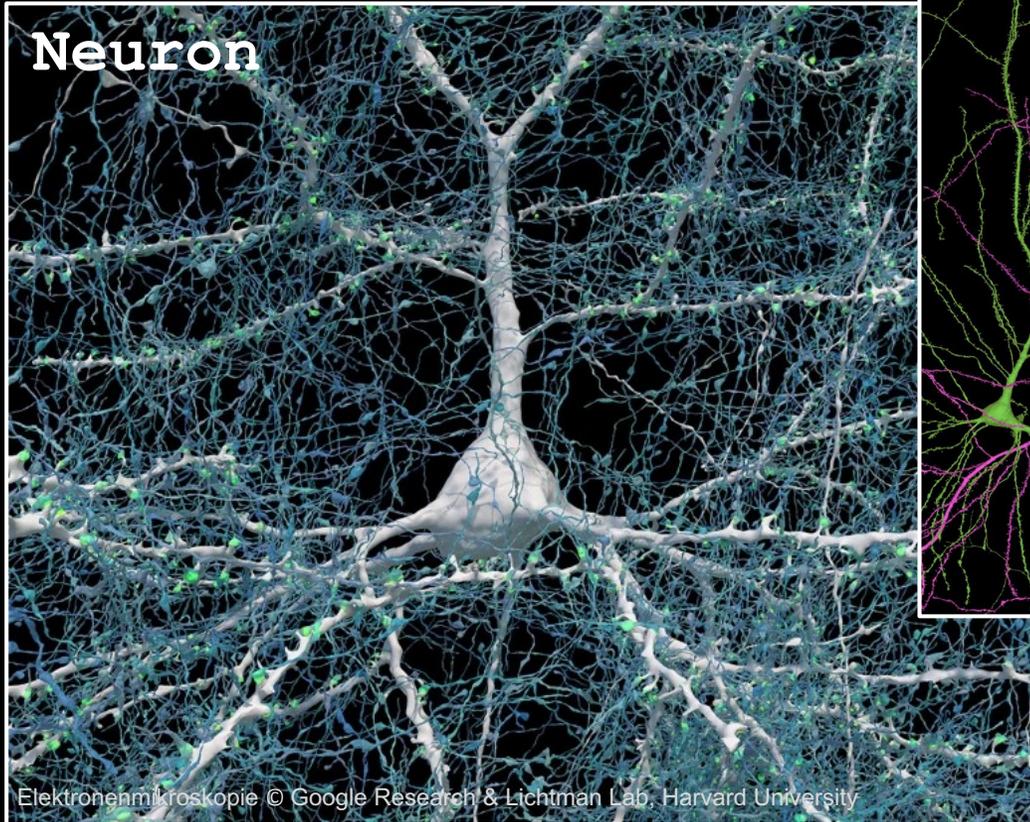
Länge Faser: $\mu\text{m} - \text{m}$

\varnothing Faser: $1 - 20 \mu\text{m}$

\varnothing Haar: $50 - 70 \mu\text{m}$



Viele Herausforderungen...



Viele Herausforderungen...

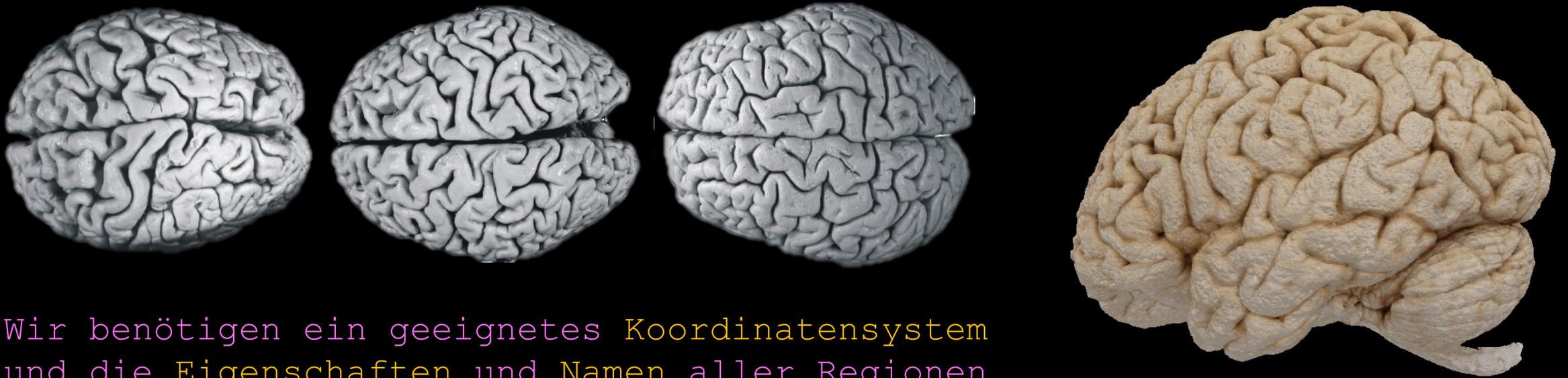
Hirnvolumen = 7 cm × 13 cm × 15 cm = 1,4 l

Es gibt ca. 86 Milliarden Neurone im adulten menschlichen Gehirn.

Jedes Neuron kann bis zu 10.000 synaptische Verbindungen eingehen.

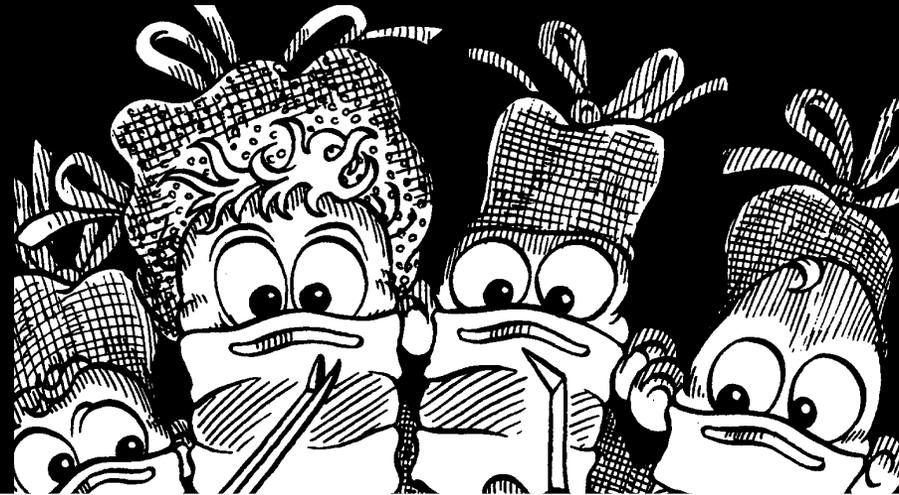
Es gibt ca. 3.000.000 km Fasern.

Gehirne unterscheiden sich teilweise sehr stark voneinander.



Wir benötigen ein geeignetes Koordinatensystem und die Eigenschaften und Namen aller Regionen aus verschiedenen „Flughöhen“ (Skalen).

Untersuchung des Gehirns nach dem Tode



Untersuchung des Gehirns nach dem Tode



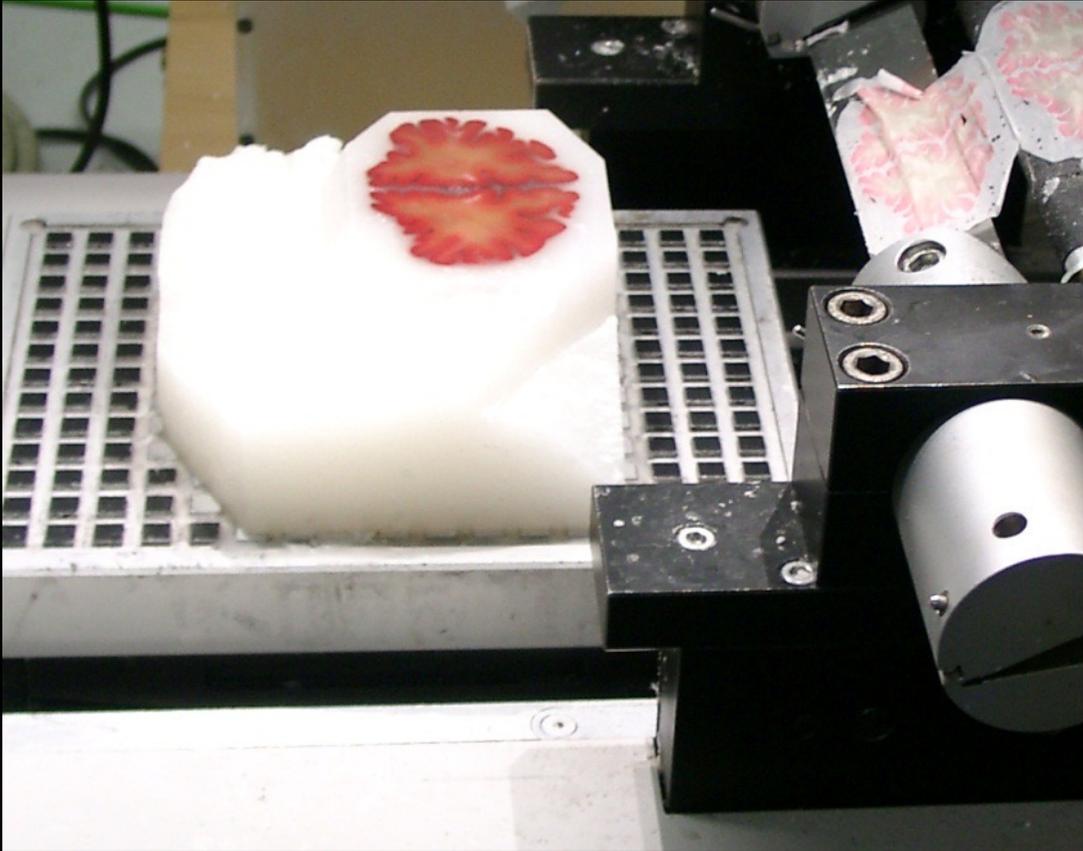
"Mind if we pick your brain?"

Hirngewebe nach Spende und Fixierung



Photogrammetrie (Oberflächen Scanning)

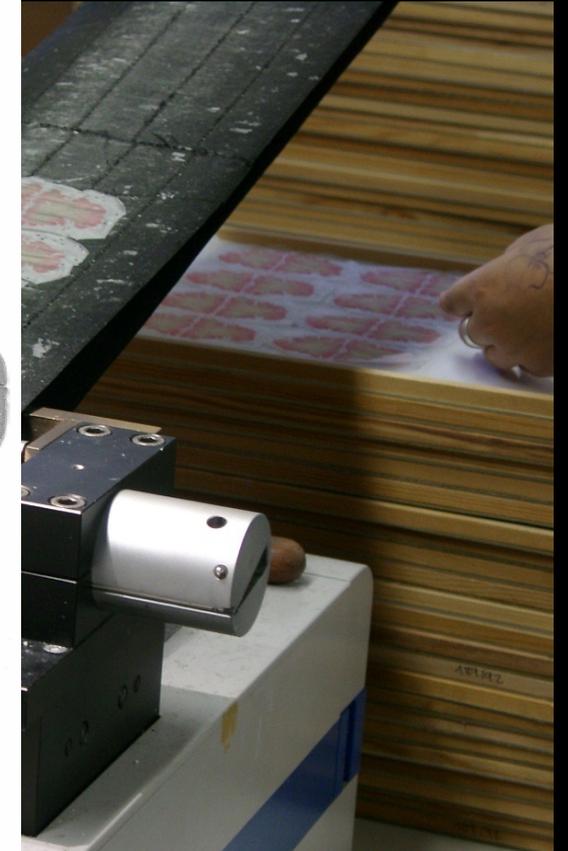
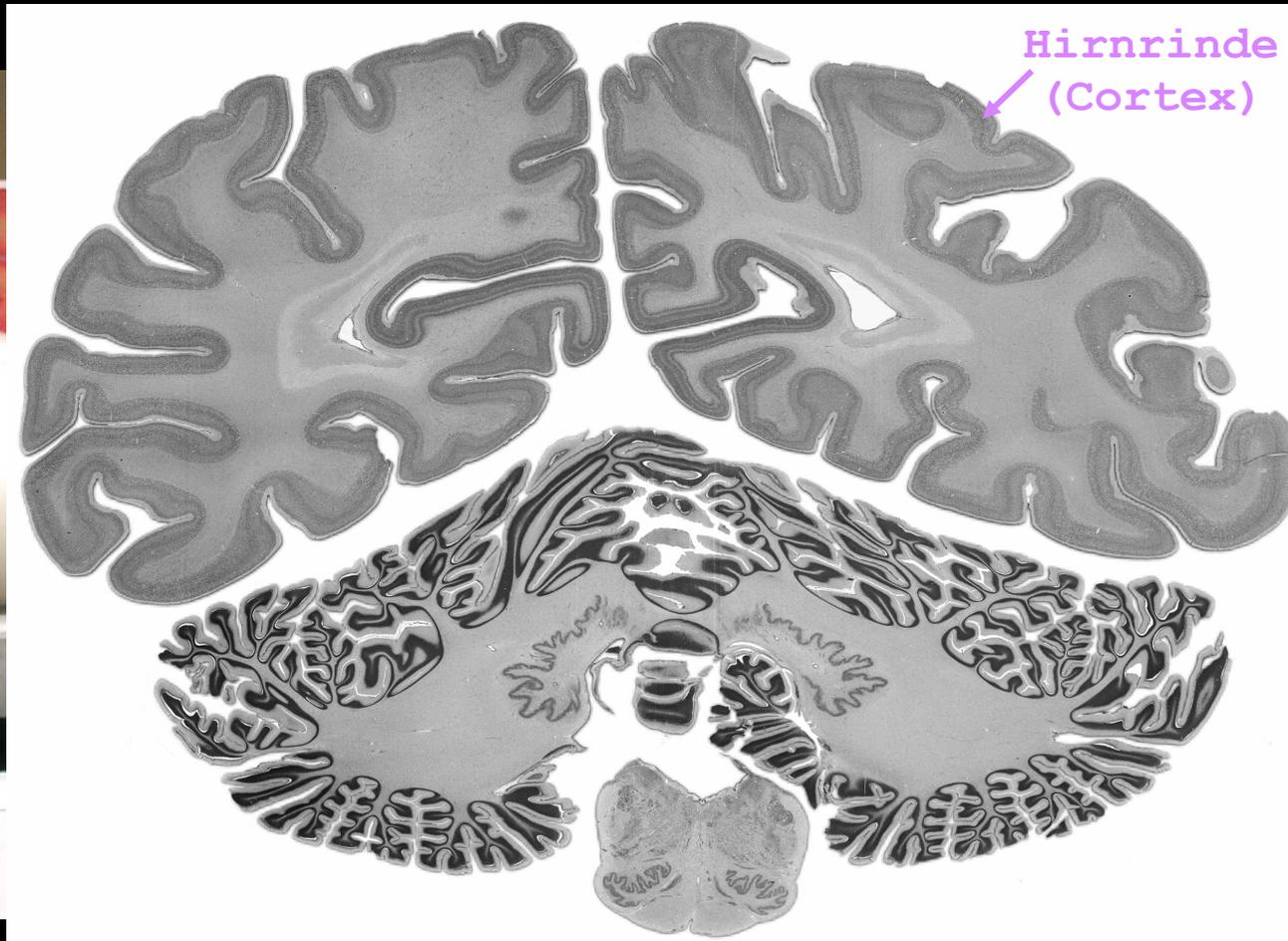
Zellarchitektur = Verteilung von Neuronen



Paraffin-Schneiden

8.000 Schnitte pro Gehirn, je 20um dick

Zellarchitektur = Verteilung von Neuronen

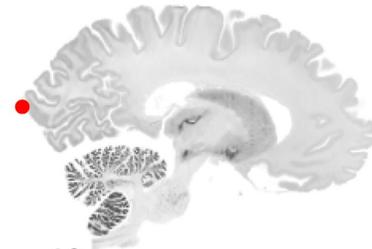


Paraffin-Schneiden

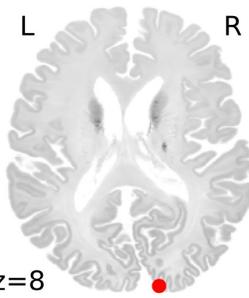
8.000 Schnitte pro Gehirn, je 20um dick

Zellarchitektur = Verteilung von Neuronen

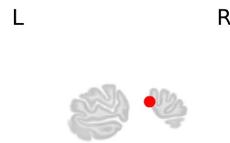
Cortex im visuellen System



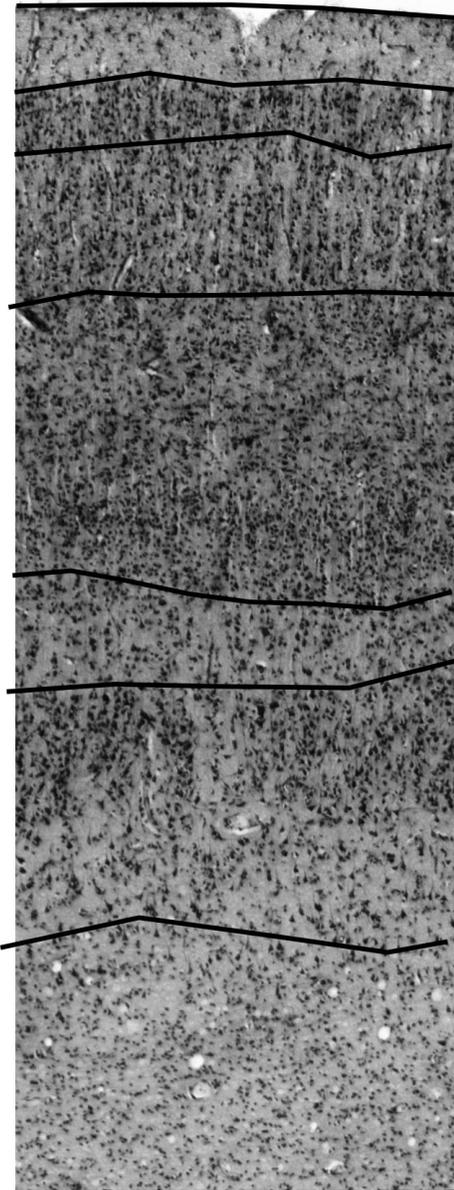
x=12



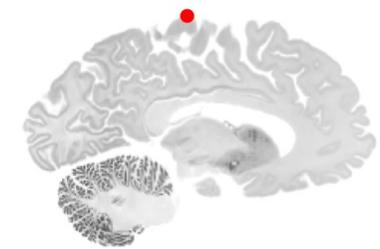
z=8



y=-65



Cortex im Motor System



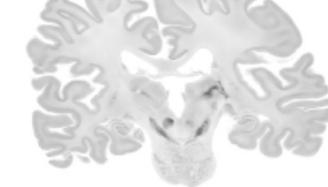
x=-12

L R

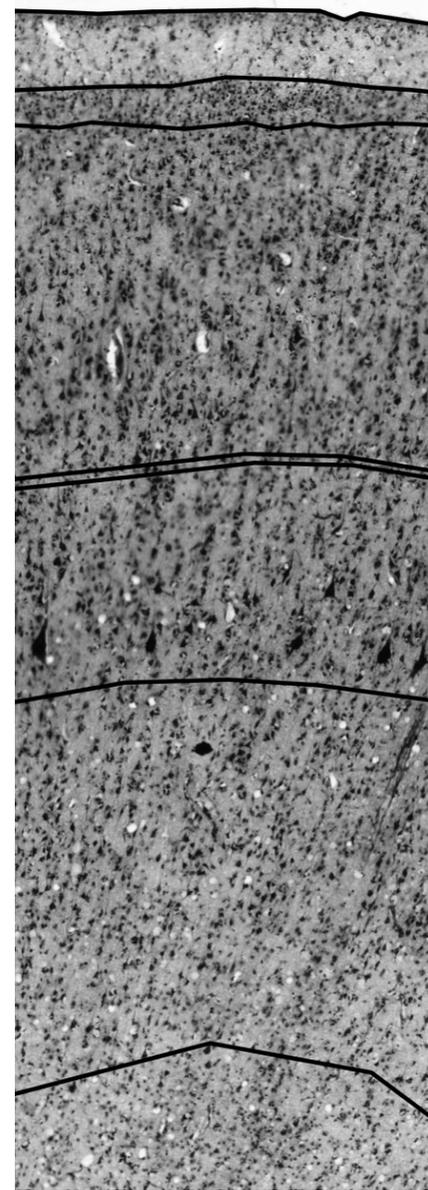


z=50

L R

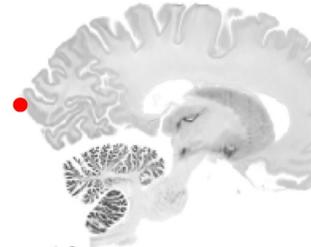
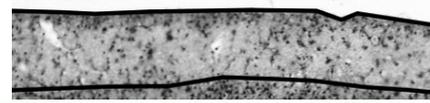
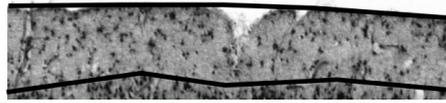


y=-1

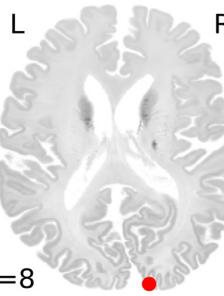


Zellarchitektur = Verteilung von Neuronen

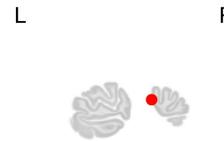
Visuelles System



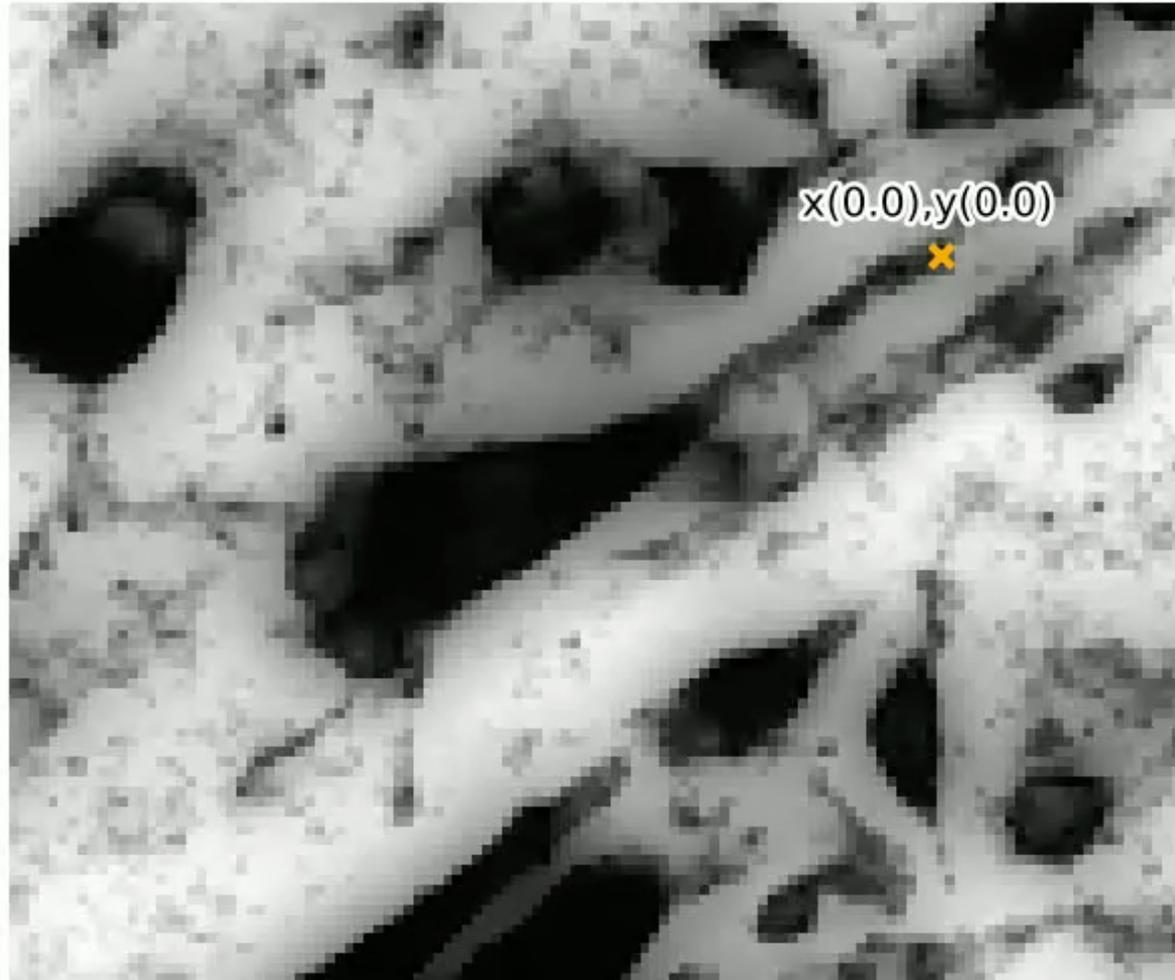
x=12



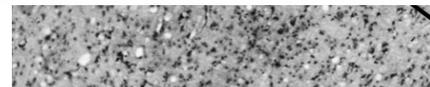
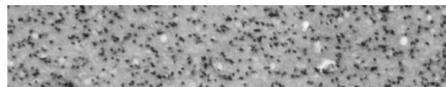
z=8



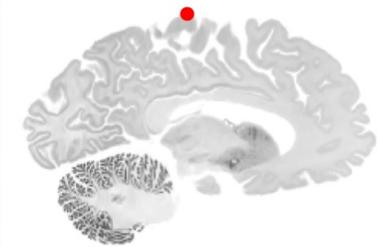
y=-65



x(0.0), y(0.0)



Motor System



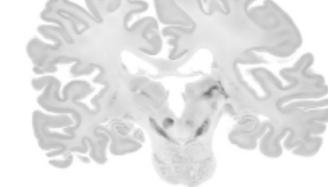
x=-12

L R



z=50

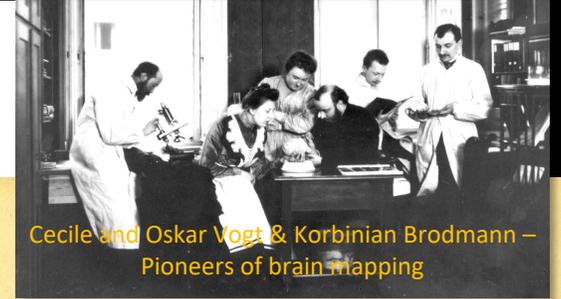
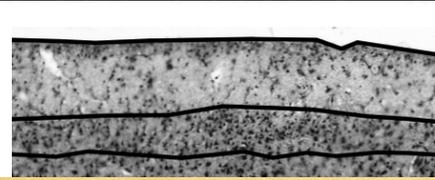
L R



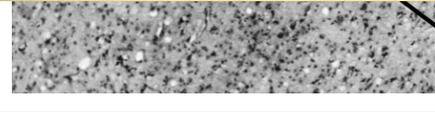
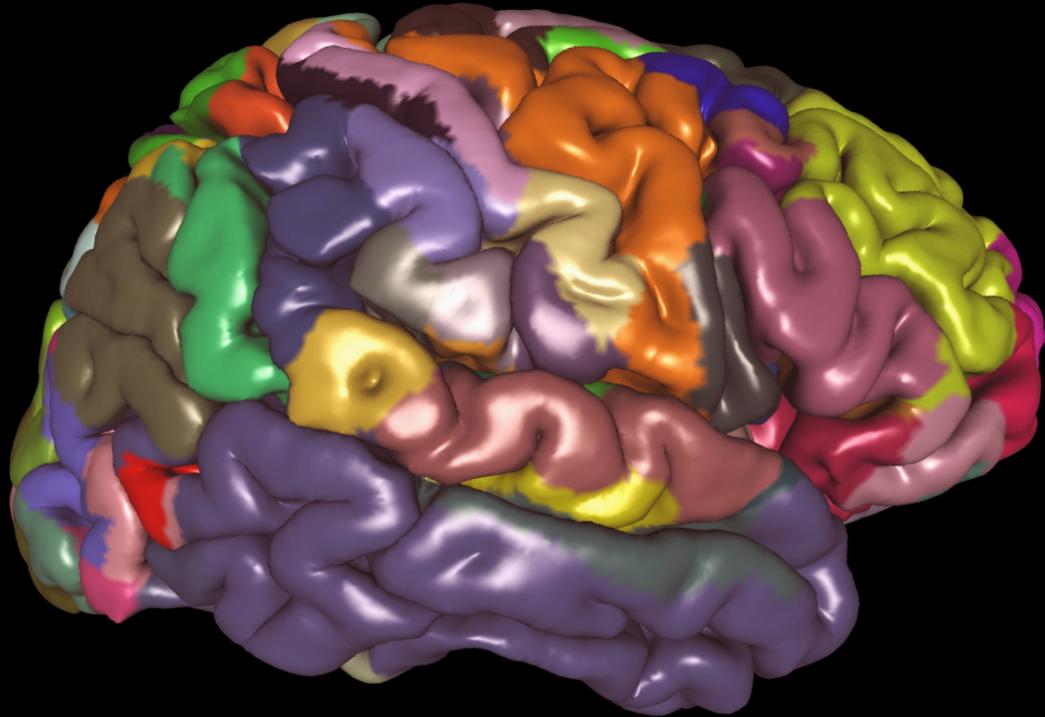
y=-1

Zellarchitektur = Verteilung von Neuronen

Visuelles System

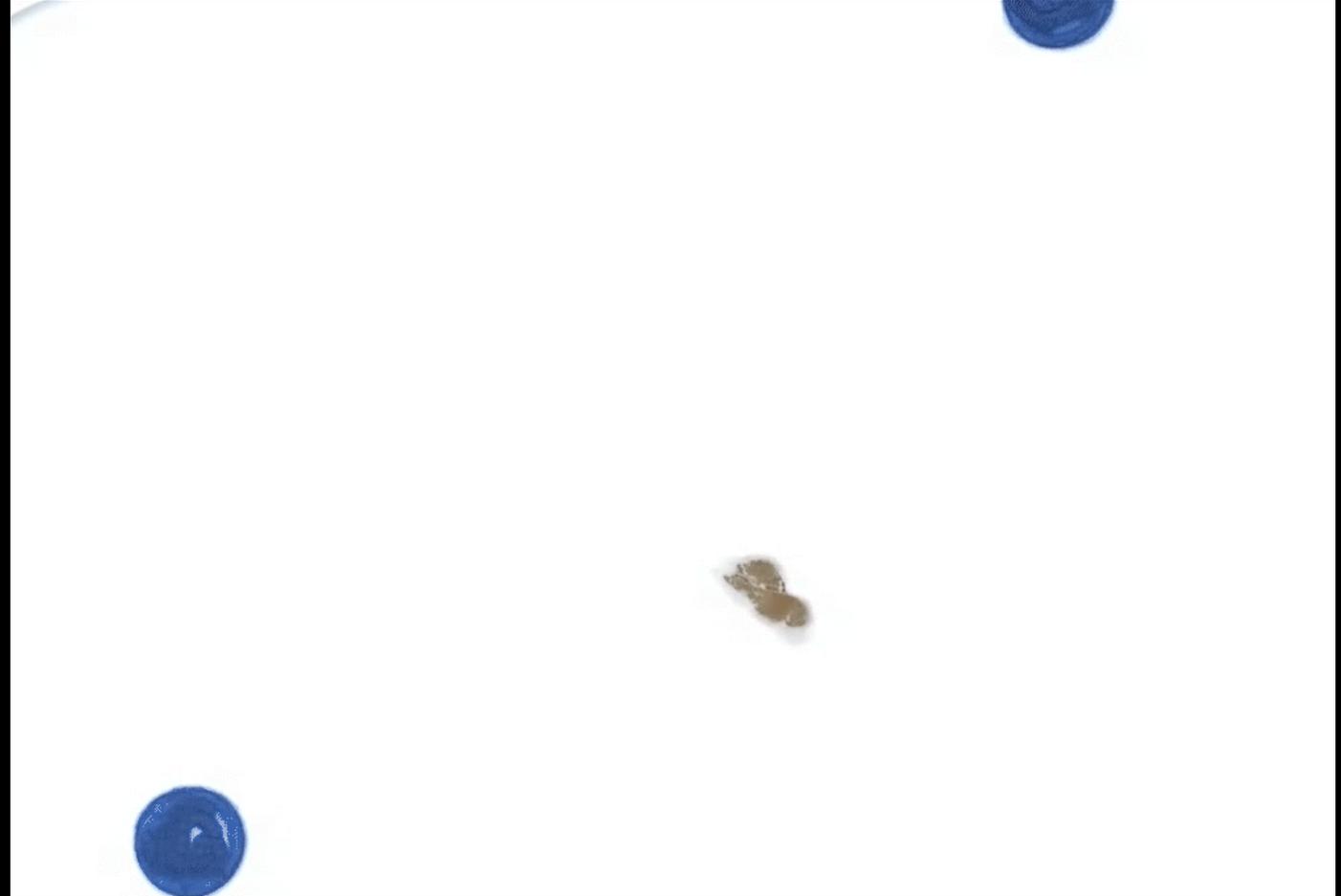


Cecile and Oskar Vogt & Korbinian Brodmann – Pioneers of brain mapping



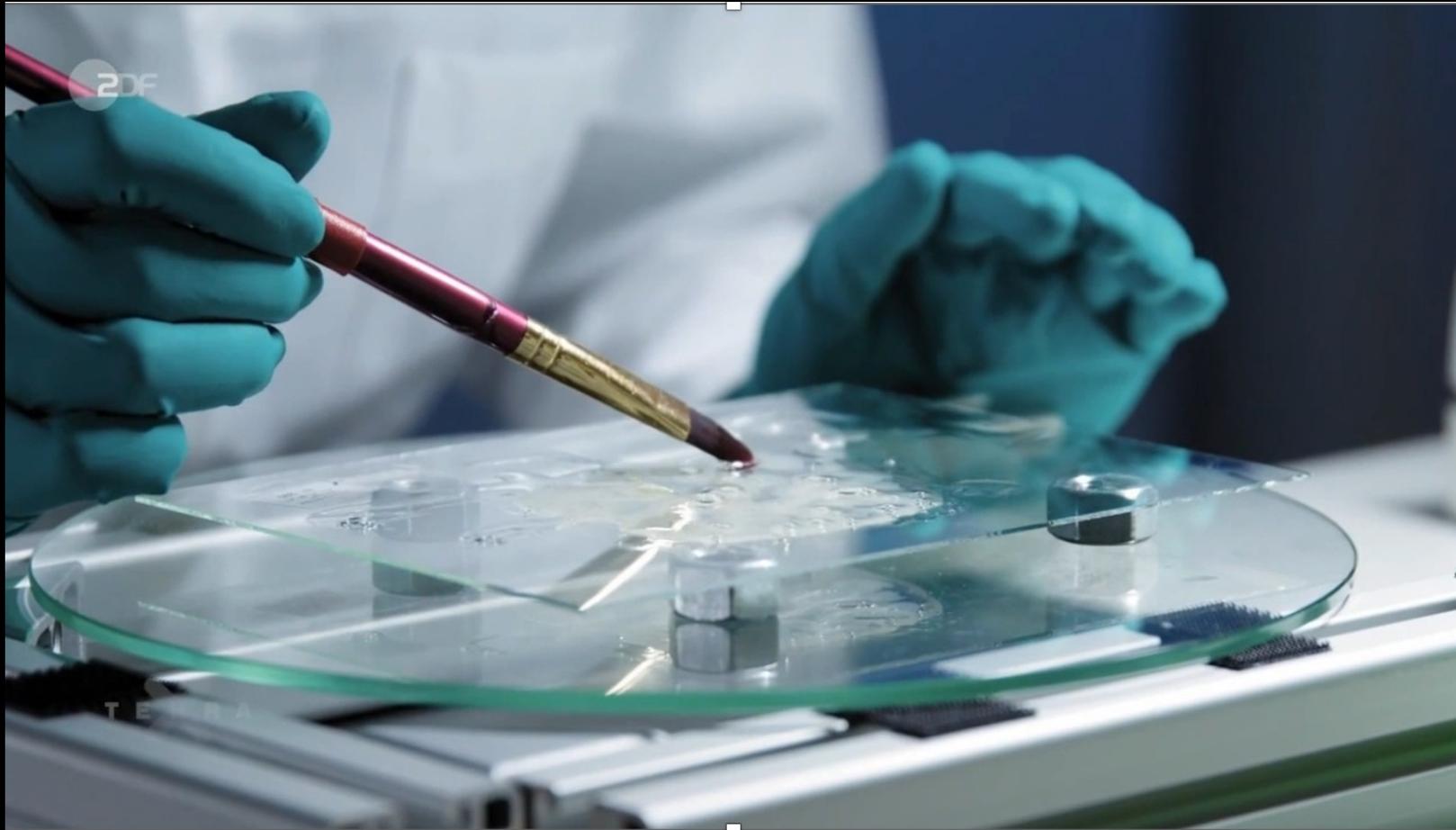
Wie macht man Nervenfaserbahnen sichtbar?

Hirnpräparation



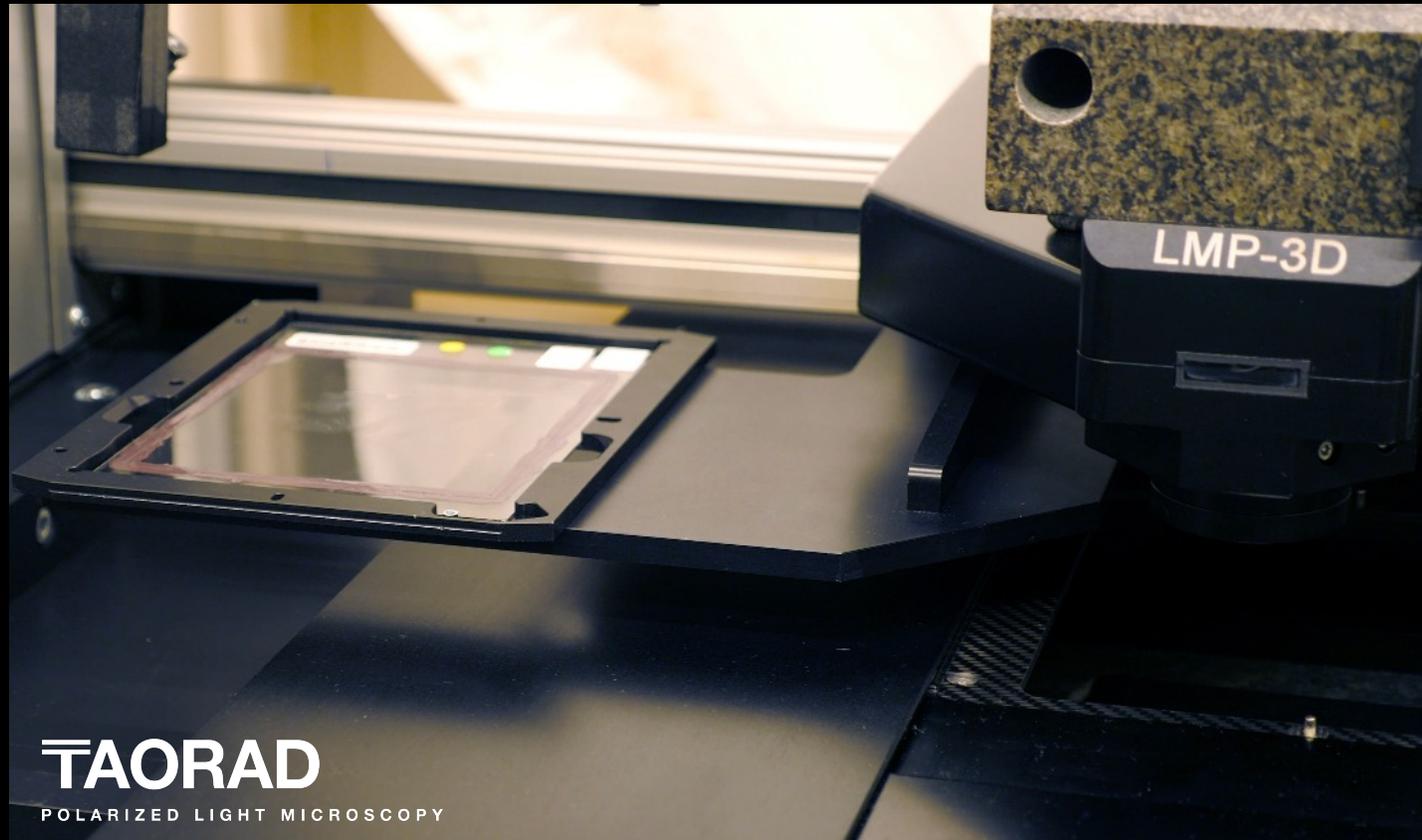
Gefrier-Schneiden und Blockface Bildgebung
3.000 Schnitte pro Gehirn, je 50um dick

Hirnpräparation



Aufziehen des Hirnschnittes und Doppelbrechungsmessung

Unsere Mikroskope



pixel size: $1.6 \mu\text{m} \times 1.6 \mu\text{m}$

file size: 20 GB

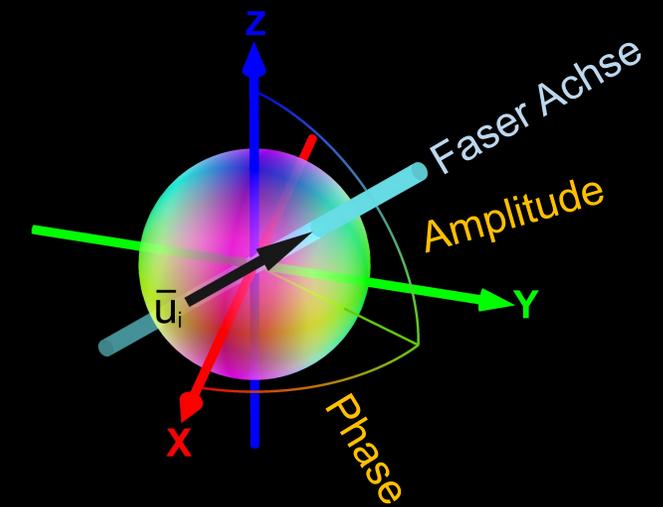
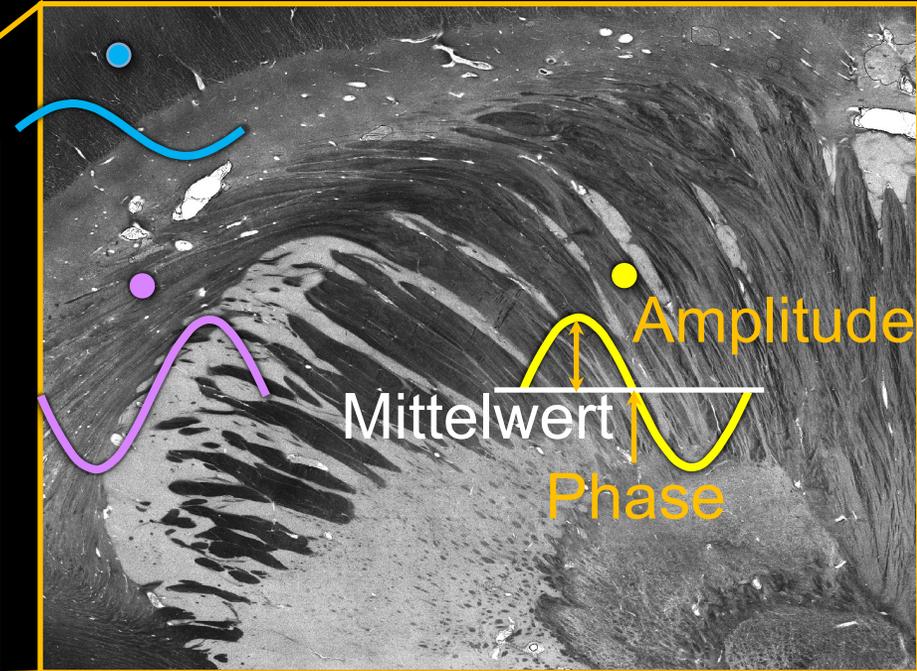
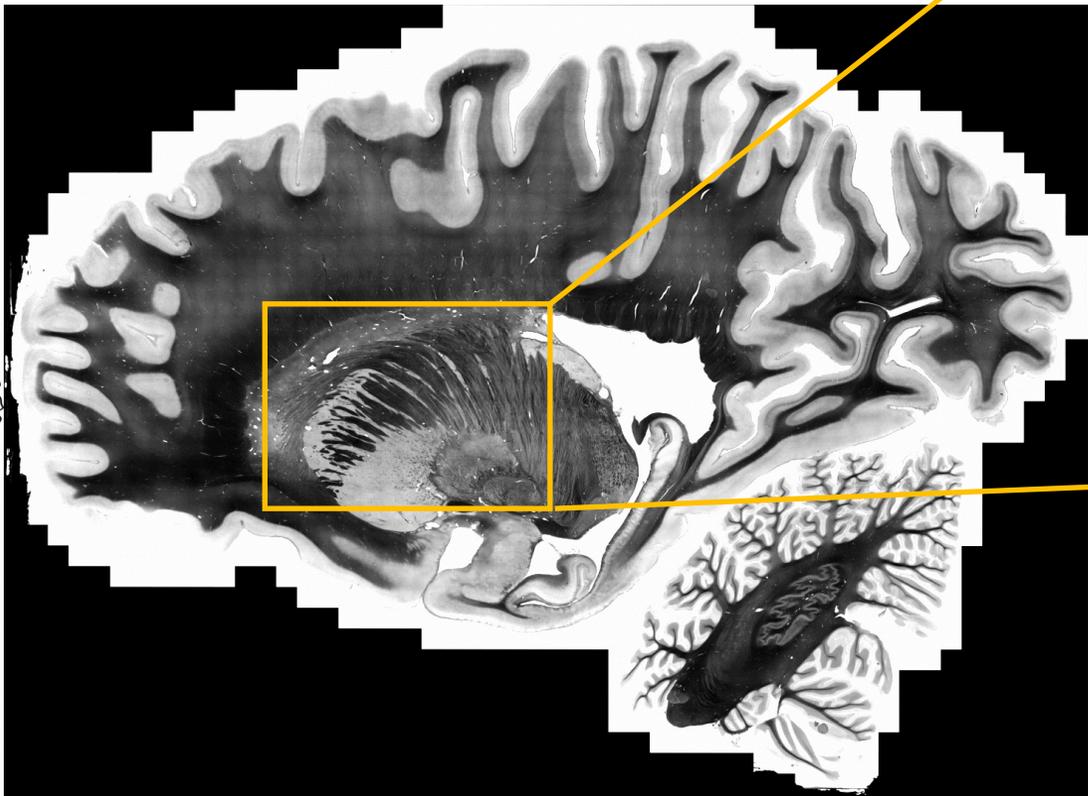
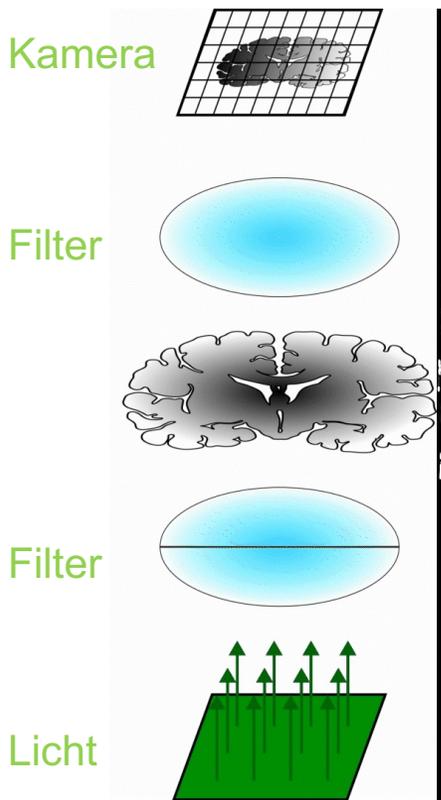
tilting light beam

(+autoloader)

Polarizing Microscope
(LMP-3D, Taorad GmbH)

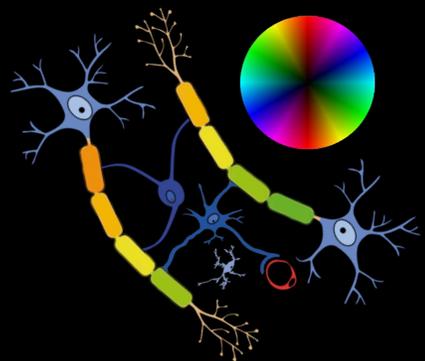
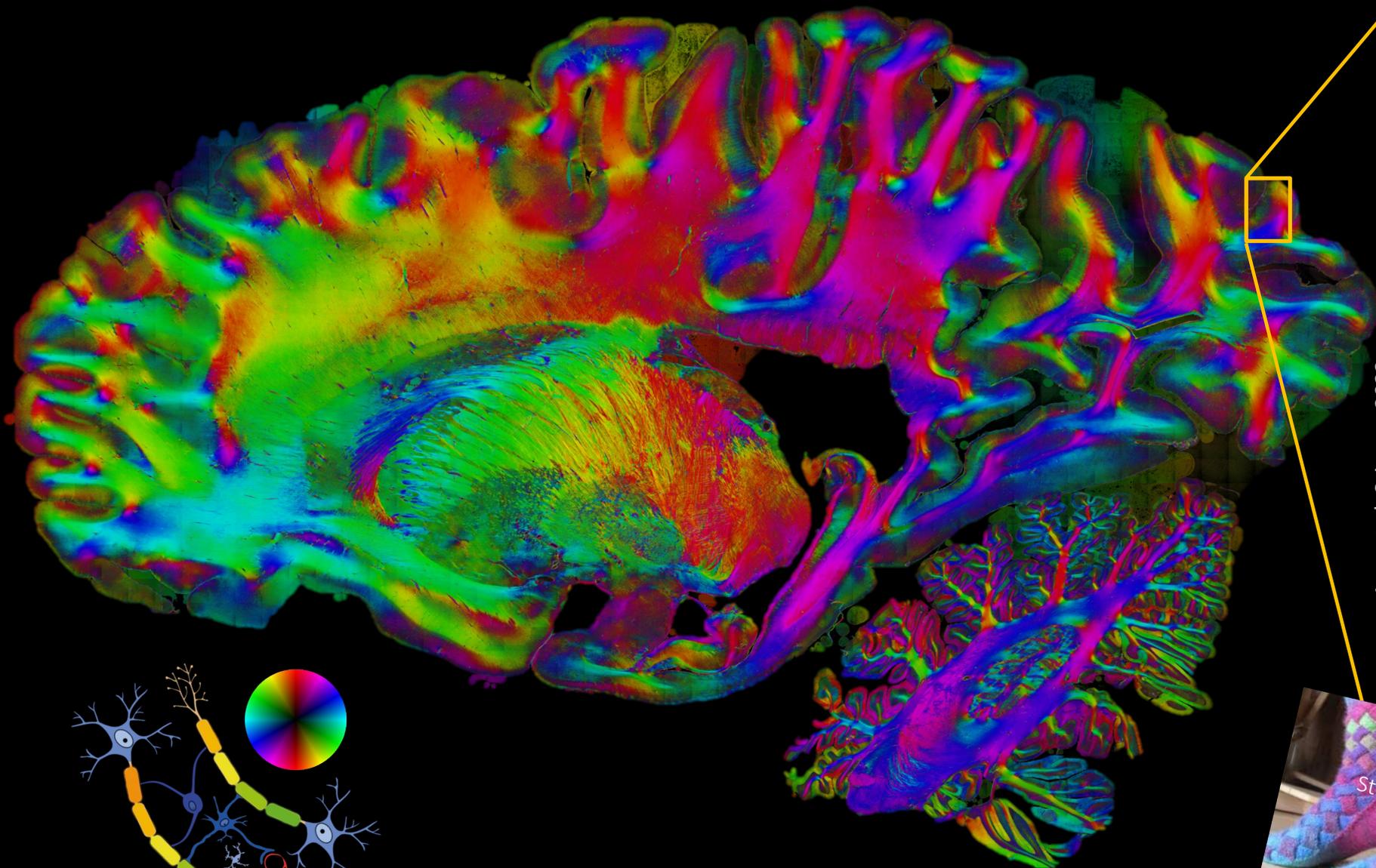
- Designed by my research teams at FZJ and BUW
- Preparing for 24/7 full-section acquisition with three scanners!

Hier wird nun die Doppelbrechung von Fasern gemessen

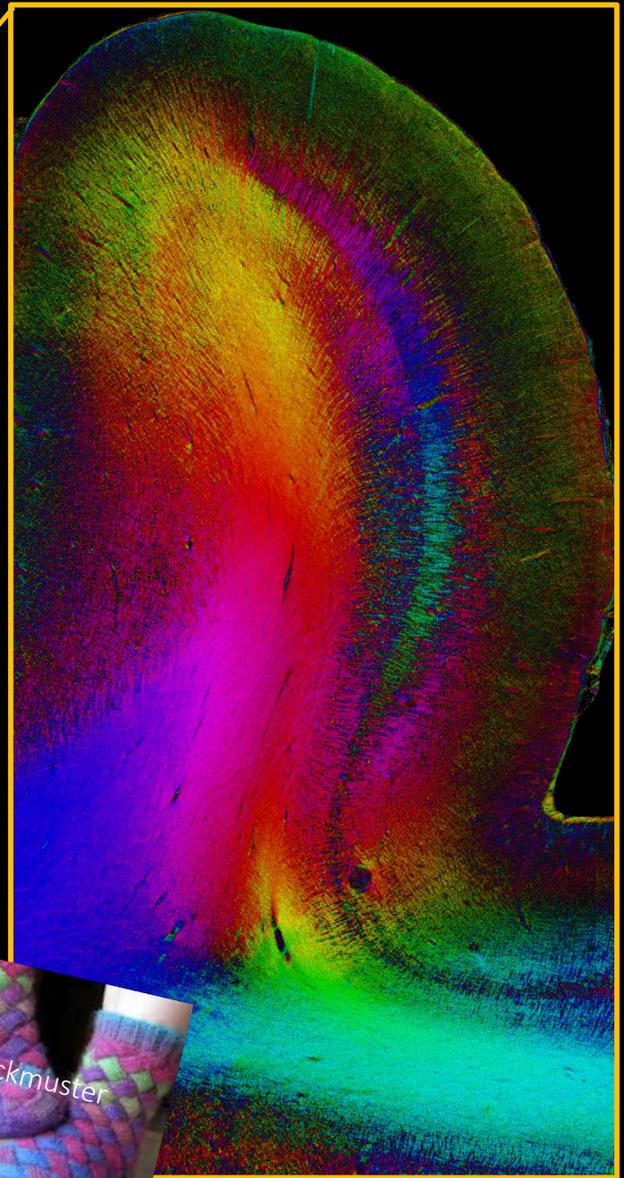


225,000 Bilder und 1 TB Speicher pro Hirnschnitt

Nervenfasern in FARBE

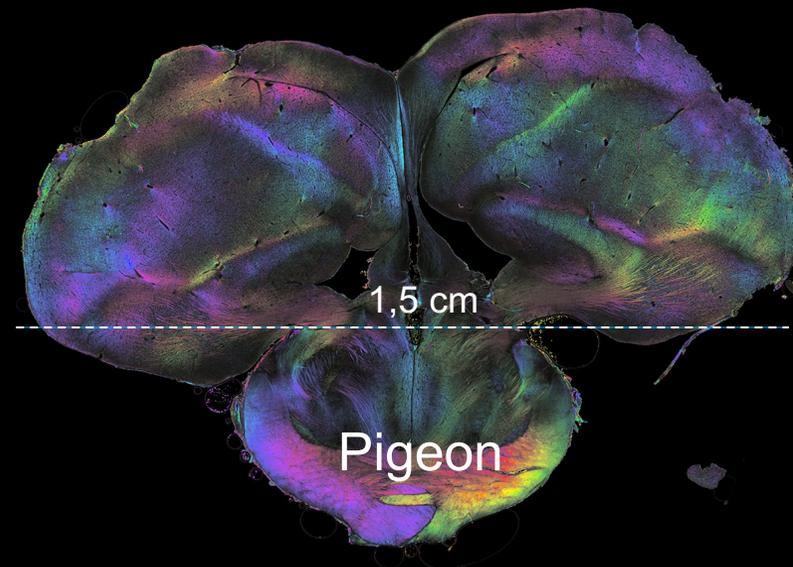
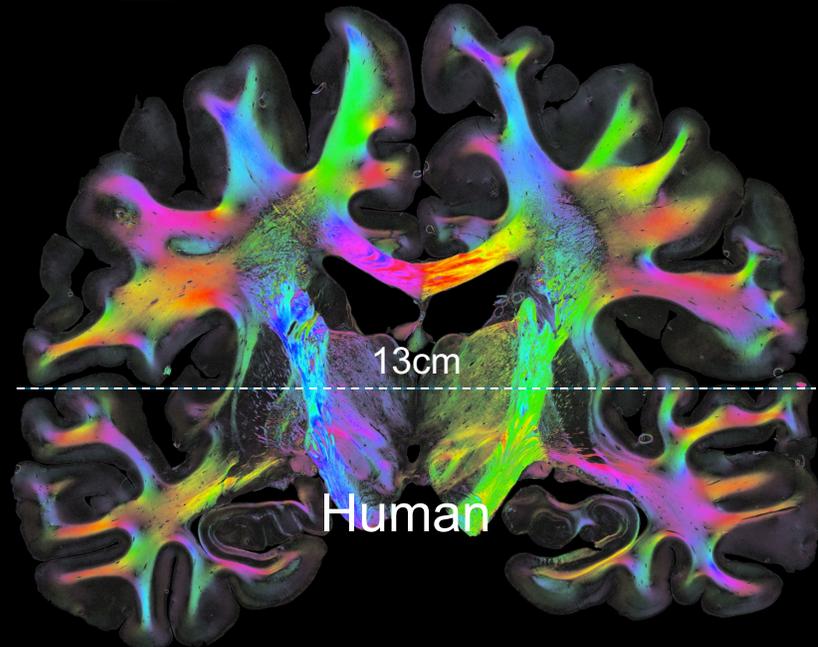
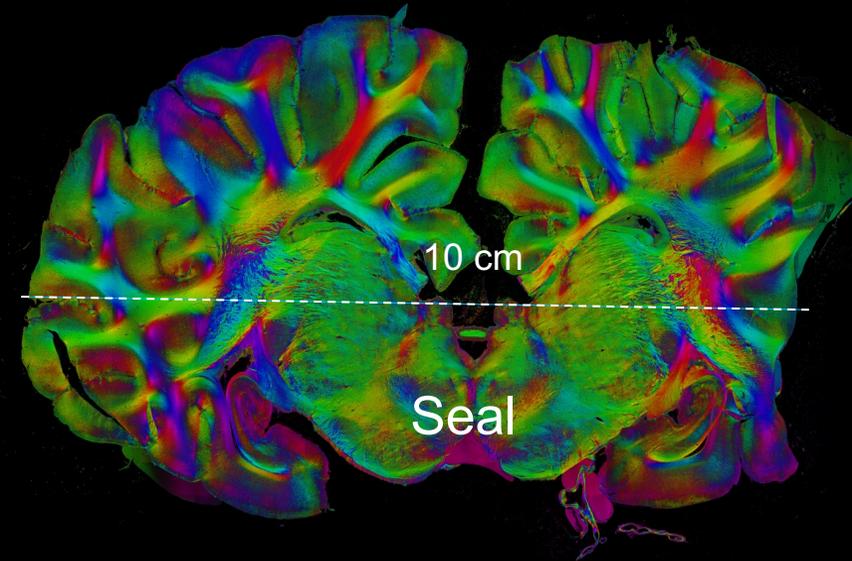
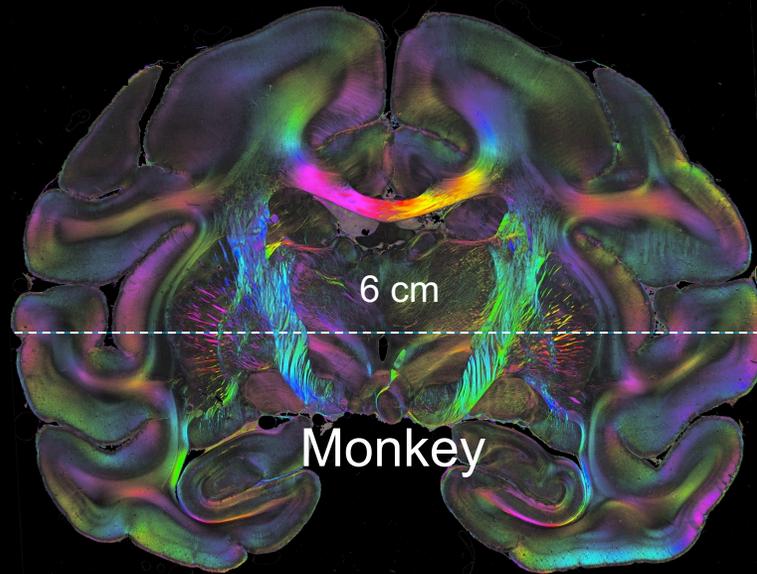
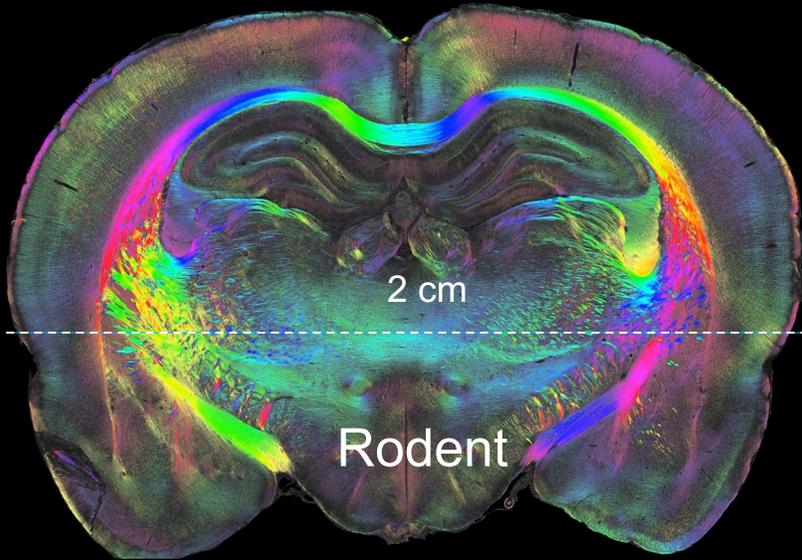


Axer et al. Science, 2022

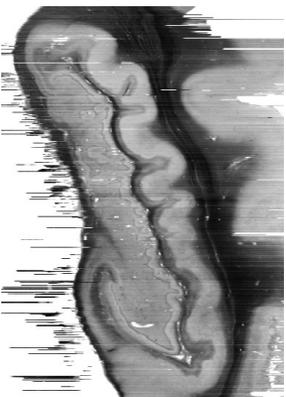
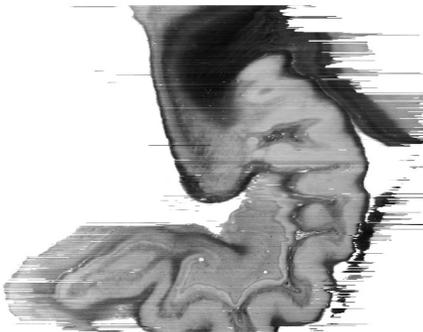
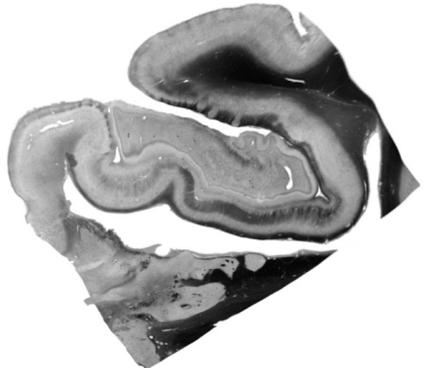


Strickmuster

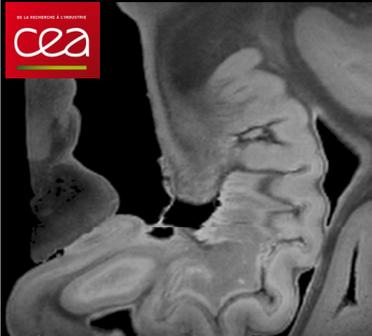
Ein Blick in verschiedene Spezies



Nervenfaseratlas in 3D

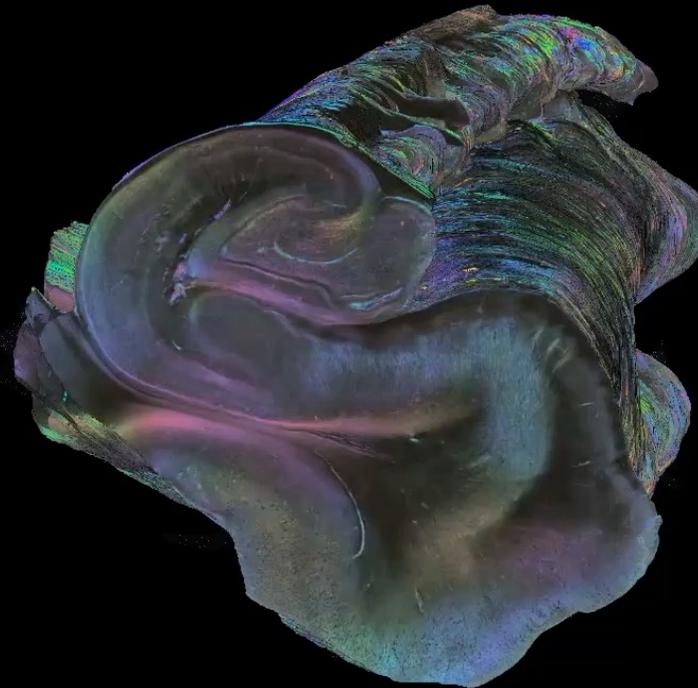


3D-PLI



Beaujoin et al., 2018

MRI T2w, 11.7T
BioSpecBruker



nature methods



Article

<https://doi.org/10.1038/s41592-025-02783-3>

HippoMaps: multiscale cartography of human hippocampal organization

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Check for updates

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Andrea Bernasconi¹, Neda Bernasconi¹, Sascha E. A. Muenzing¹,
Markus Axer^{6,7}, Katrin Amunts^{8,9}, Alan C. Evans¹⁰ &
Boris C. Bernhardt^{10,11}



Google Brain: Ein Atlas fürs Gehirn

Wie baut man Mikroskope für diesen Zweck?

Kann KI uns bei der Analyse helfen?

