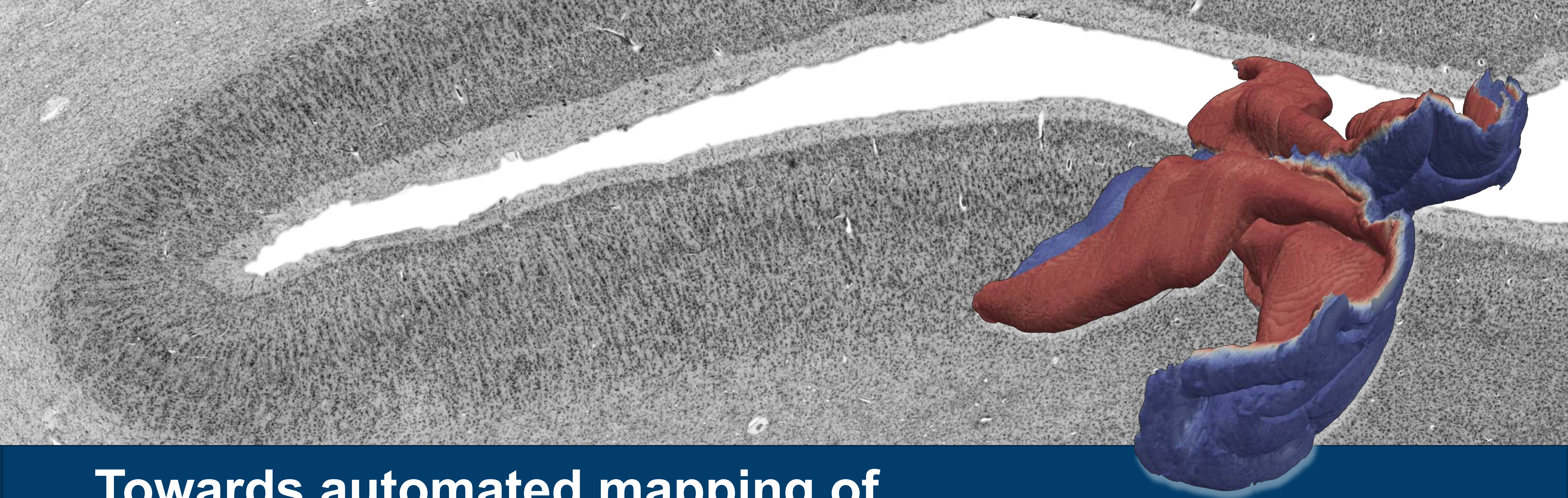


Towards automated mapping of cytoarchitectonic areas using Deep Learning

TIMO DICKSCHEID | BIG DATA ANALYTICS | INSTITUTE OF NEUROSCIENCE AND MEDICINE (INM-1)

2020 JUN 26

Mitglied der Helmholtz-Gemeinschaft

HIBALL HELMHOLTZ International BigBrain Analytics & Learning Laboratory

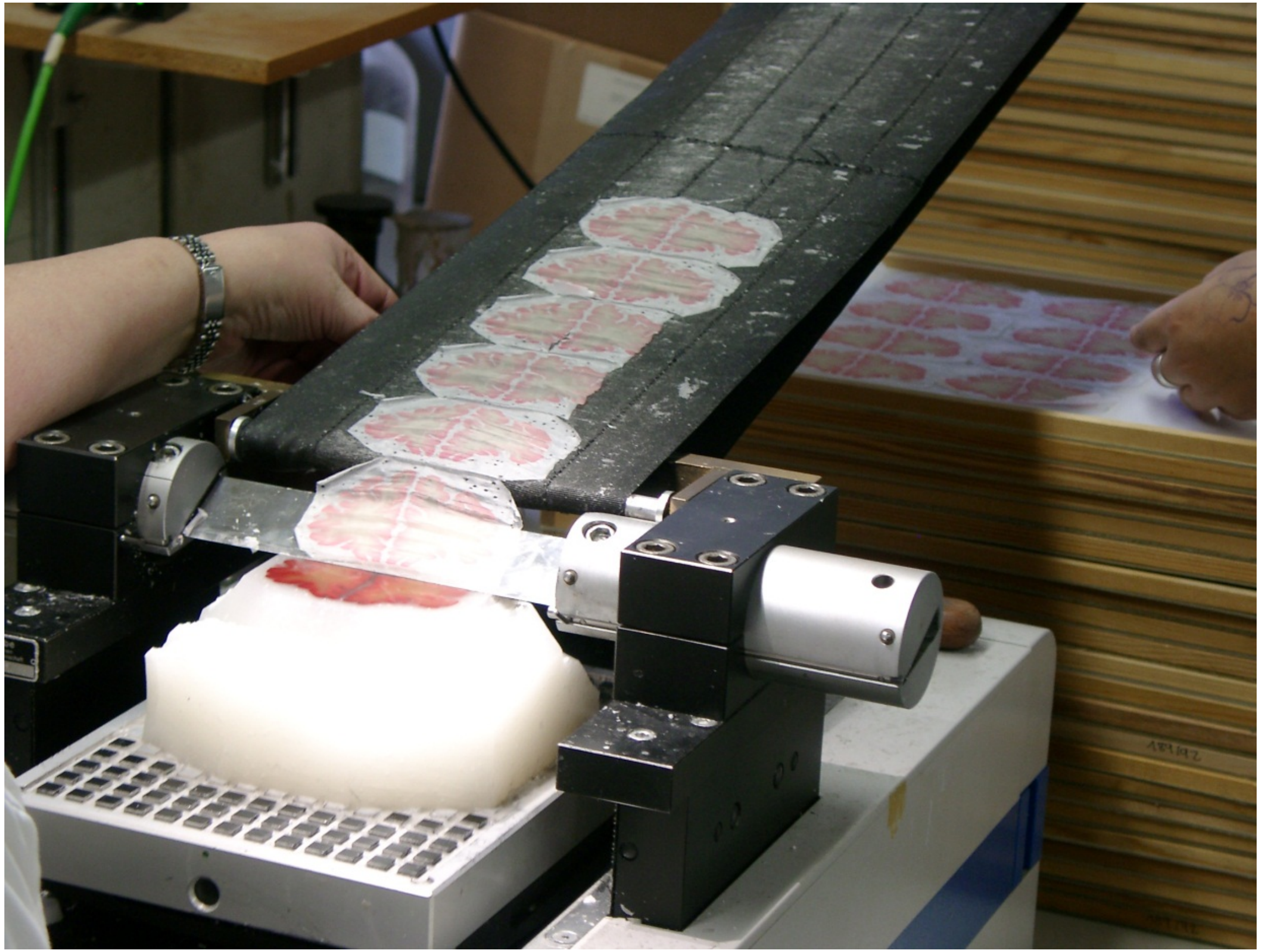
Human Brain Project

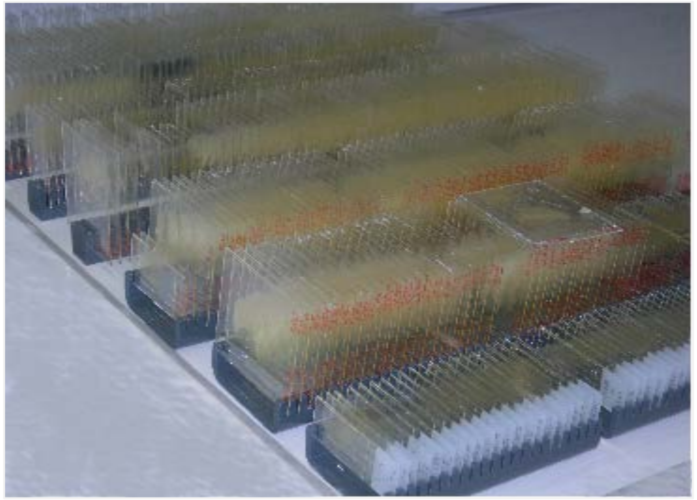
SPP 2041 Computational Connectomics

HELMHOLTZ AI

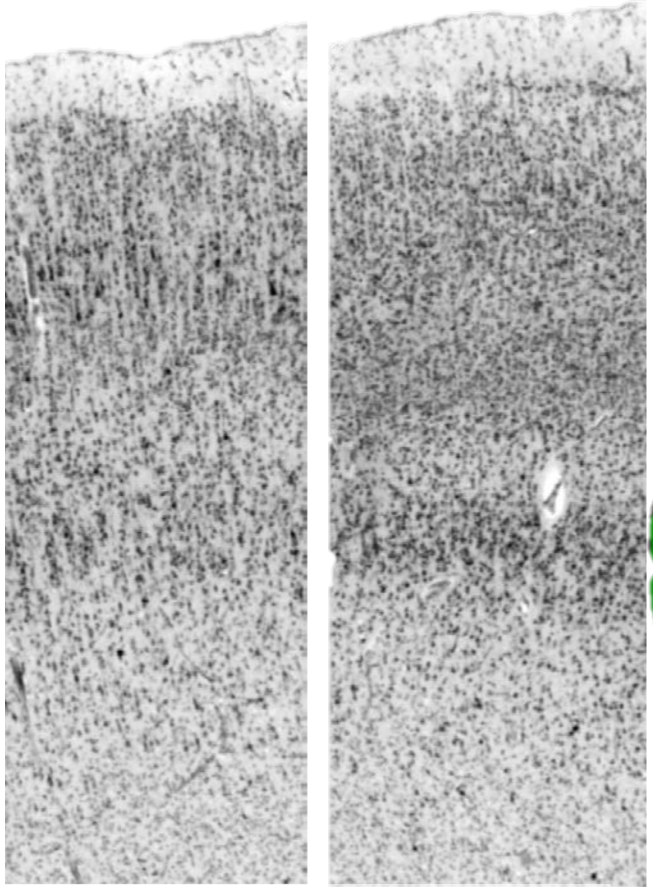
JÜLICH Forschungszentrum

Production of whole brain sections

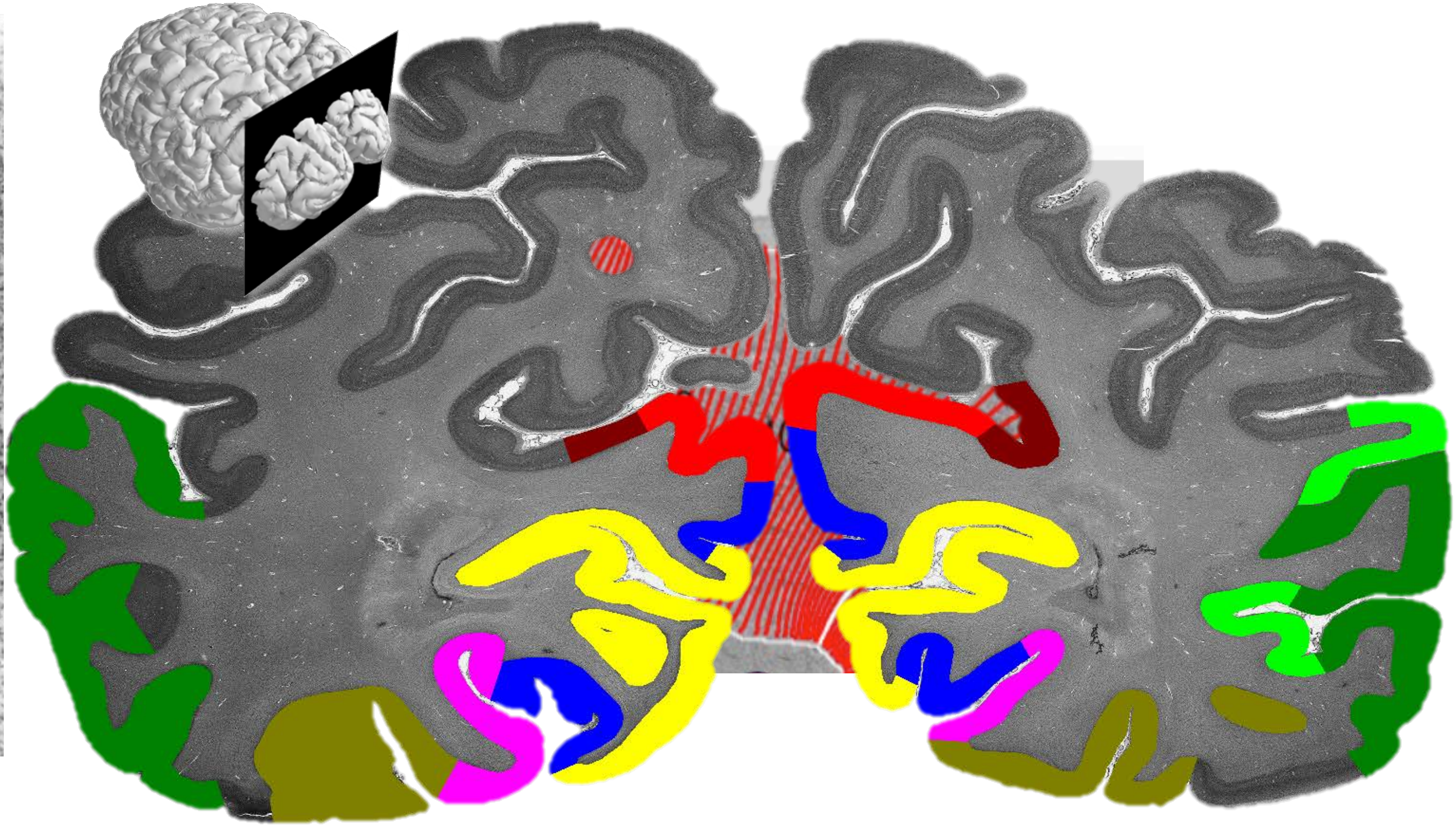




Cytoarchitectonic mapping in serial sections



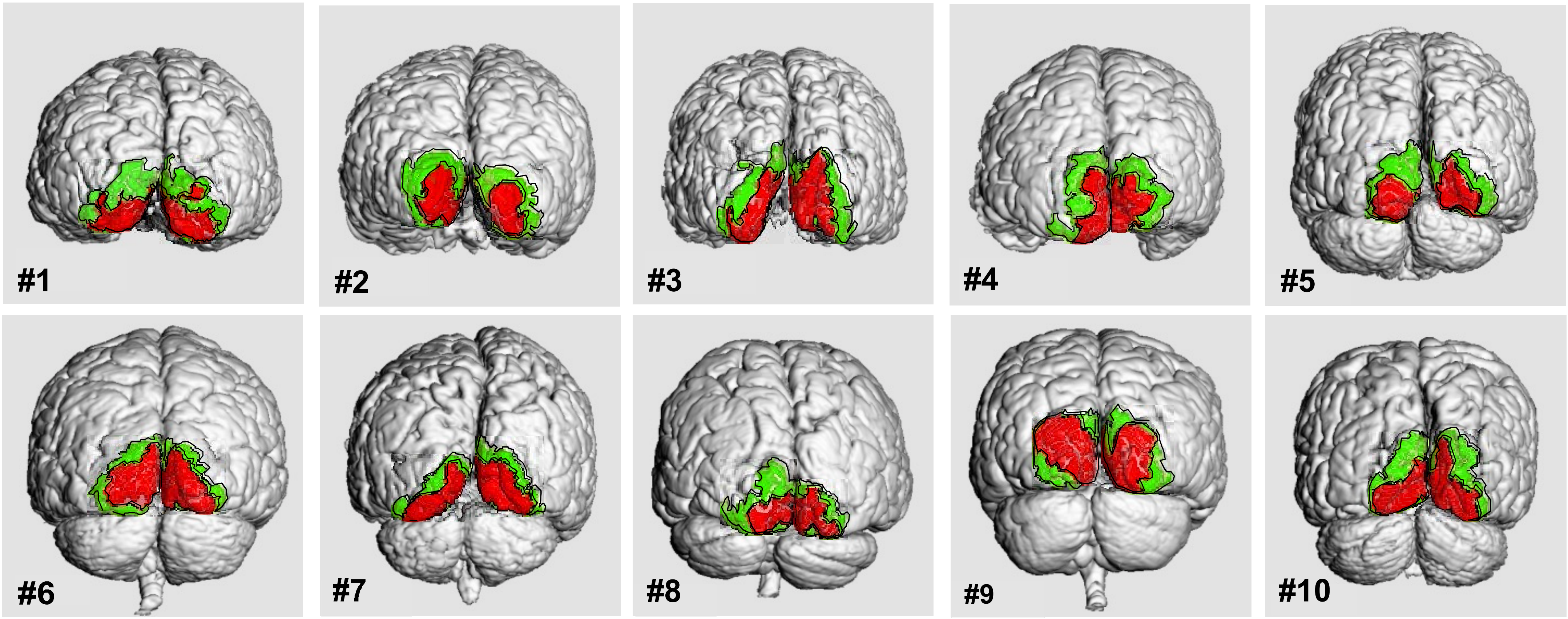
Amunts, K. and K. Zilles, Architectonic Mapping of the Human Brain beyond Brodmann. Neuron 2015. 88(6)



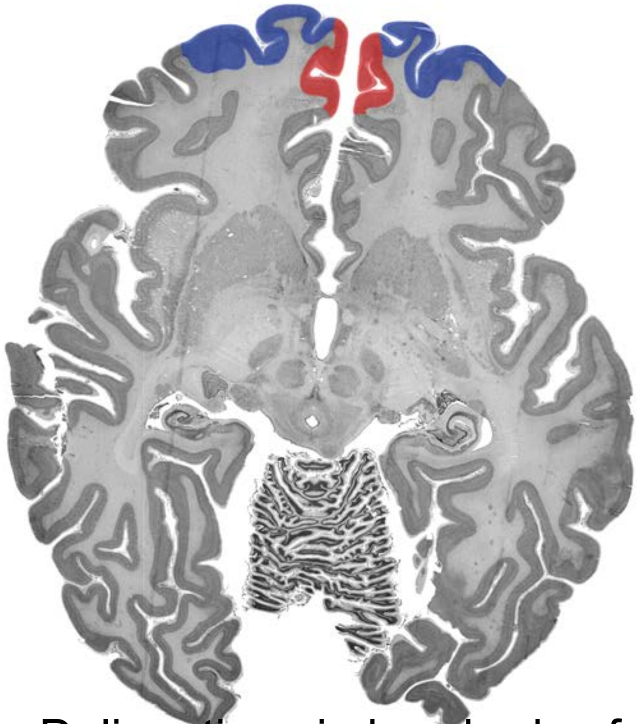
JÜLICH Forschungszentrum

Capturing intersubject variability

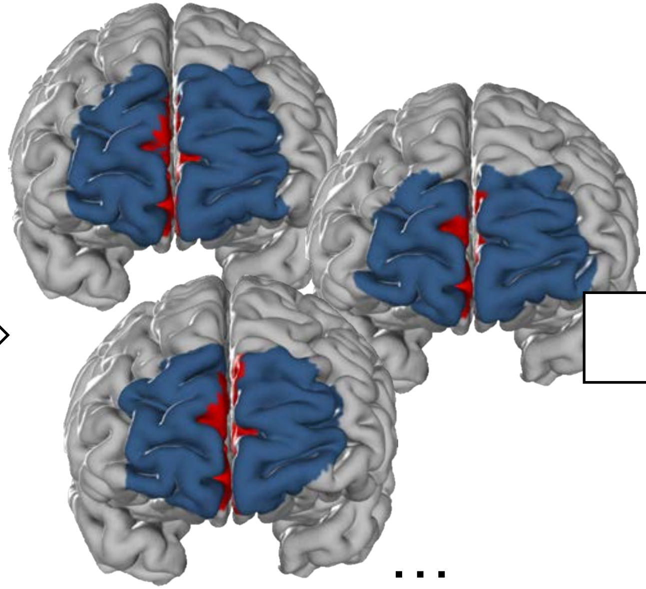
Amunts, Zilles et al.: Brodmann's Areas 17 and 18 Brought into Stereotaxic Space—Where and How Variable?, NeuroImage, Volume 11, Issue 1, 2000, Pages 66-84



Julich-Brain: cytoarchitectonic probabilistic maps

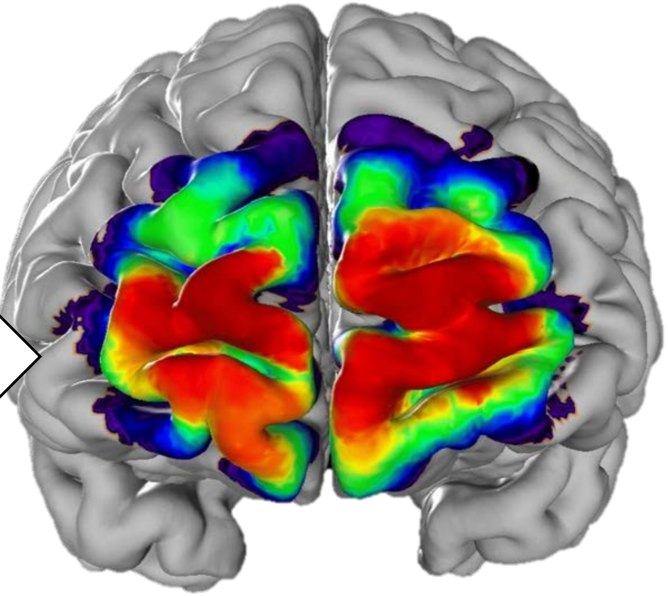


Delineations in hundreds of
sections in 10 individual brains
[micrometer scale]



Individual delineations projected to
MNI reference space
[mm scale]

Bludau et al. 2014

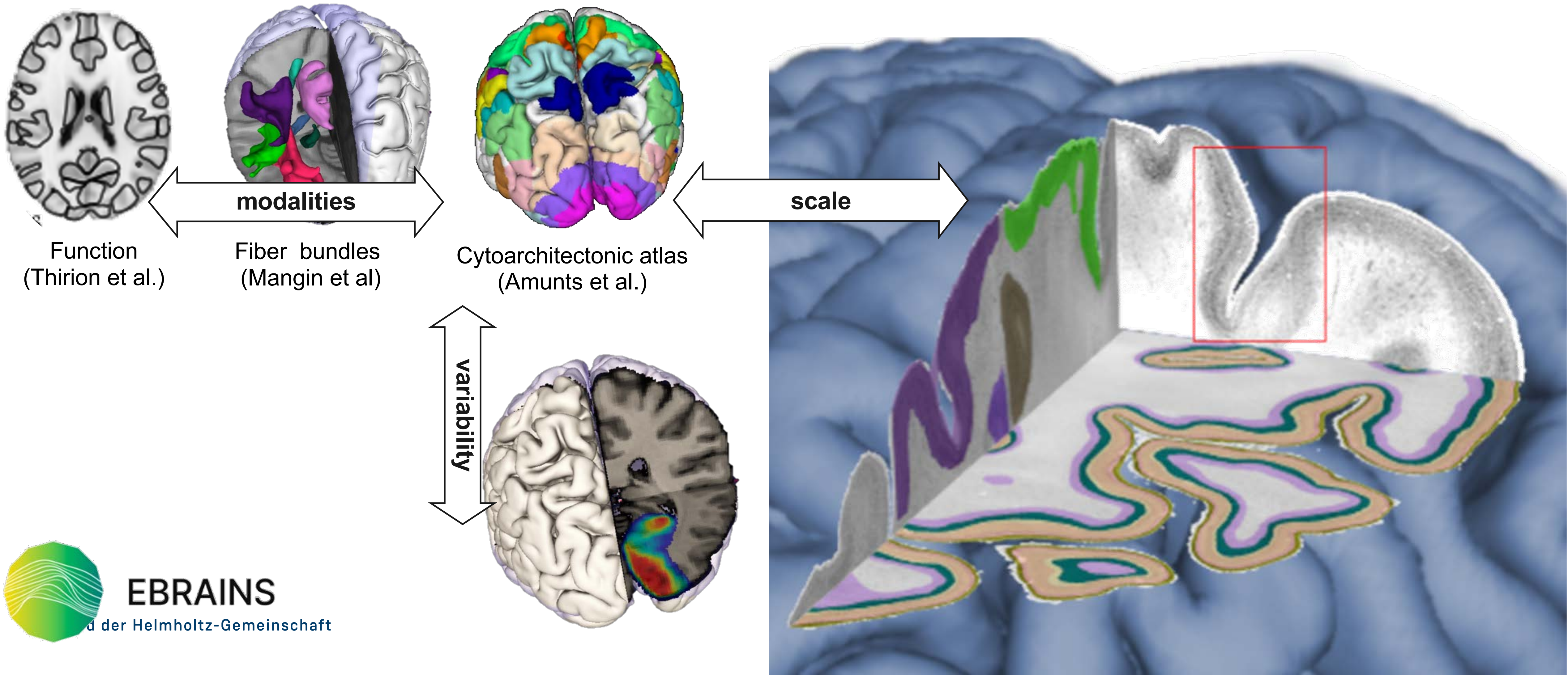


Probabilistic map
[mm scale]

Building a multilevel human brain atlas using BigBrain

Region definitions in MNI space

Region definitions at the microscopic scale in BigBrain space

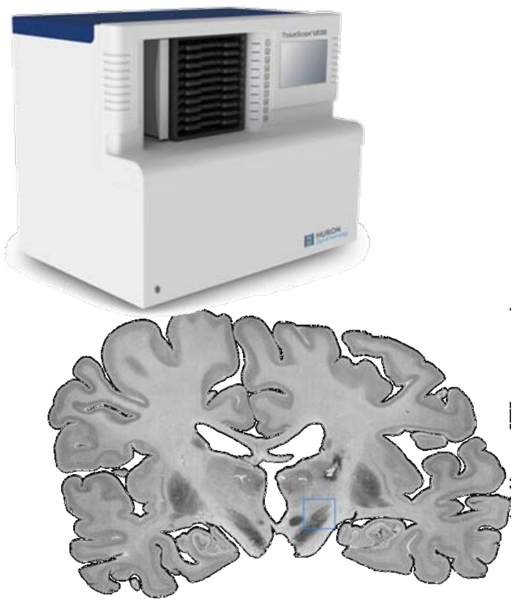


EBRAINS

d der Helmholtz-Gemeinschaft

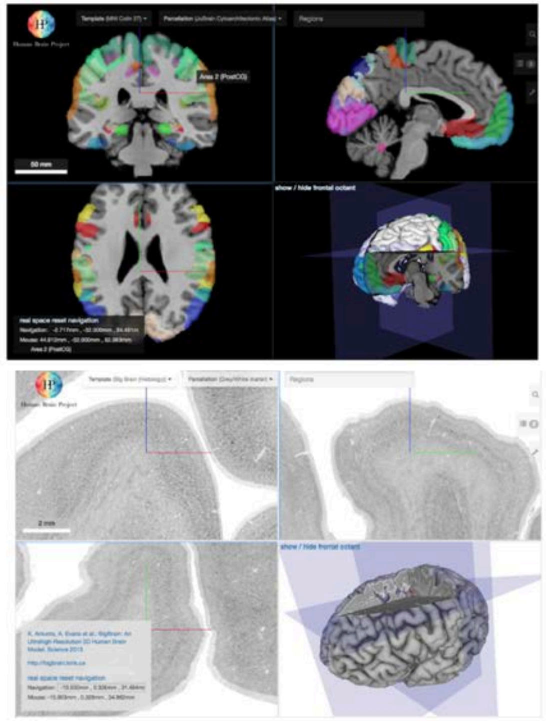
Aim: From the lab to the web at high throughput

using Big Data Analytics on High Performance Computers



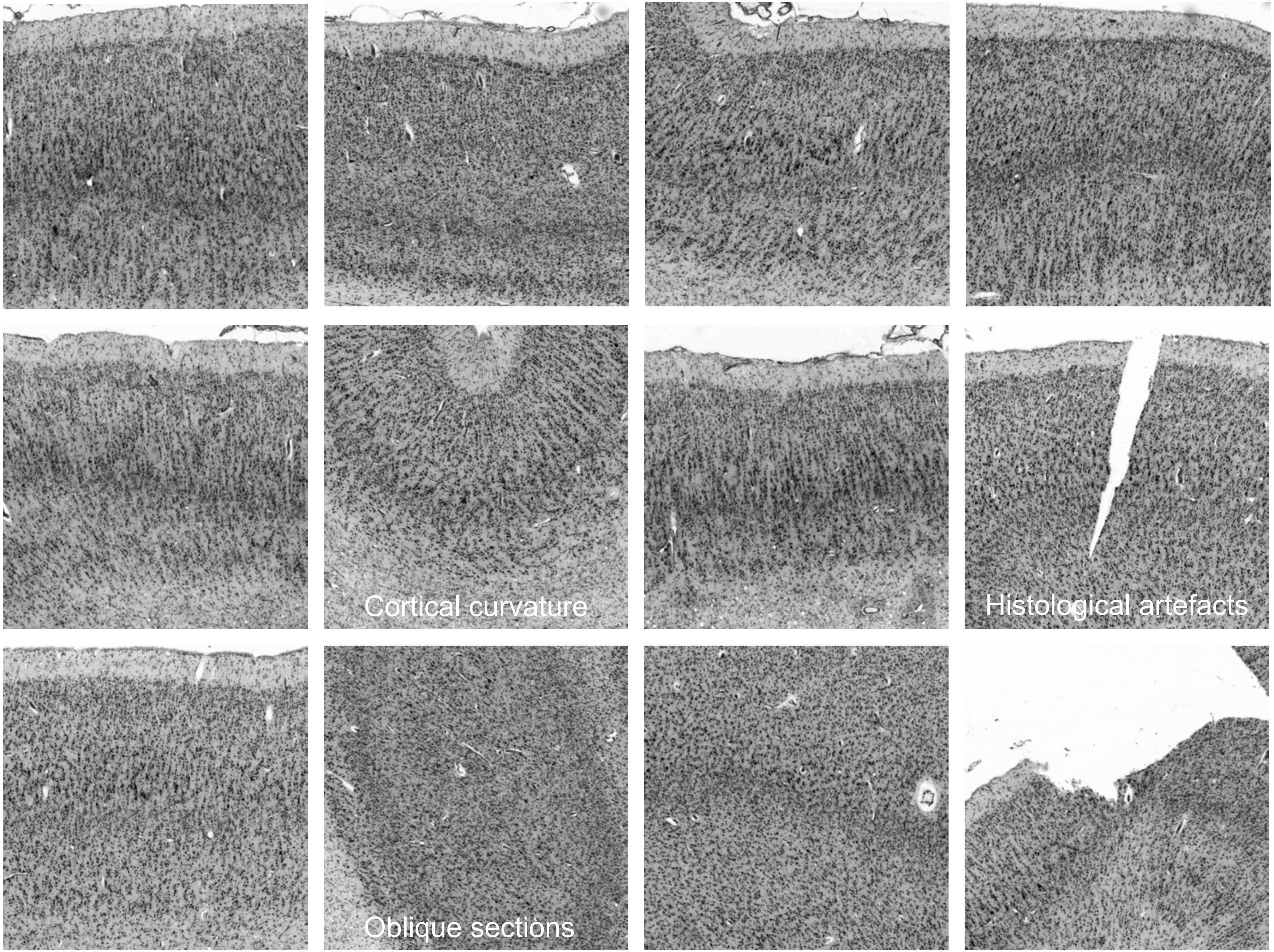
High throughput microscopic imaging (Terabytes / day)

Automated brain mapping workflows across thousands of image sections



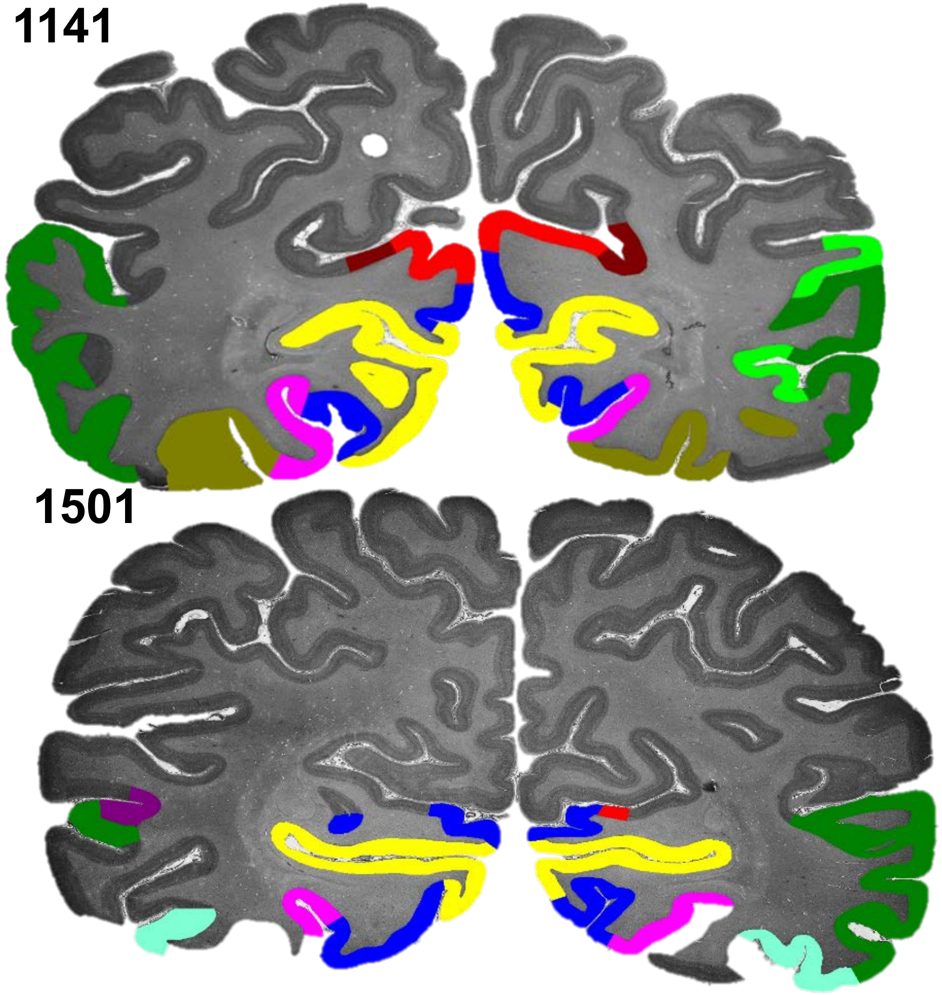
Interactive online access to maps and image data

Automating cytoarchitectonic mapping with Deep Learning

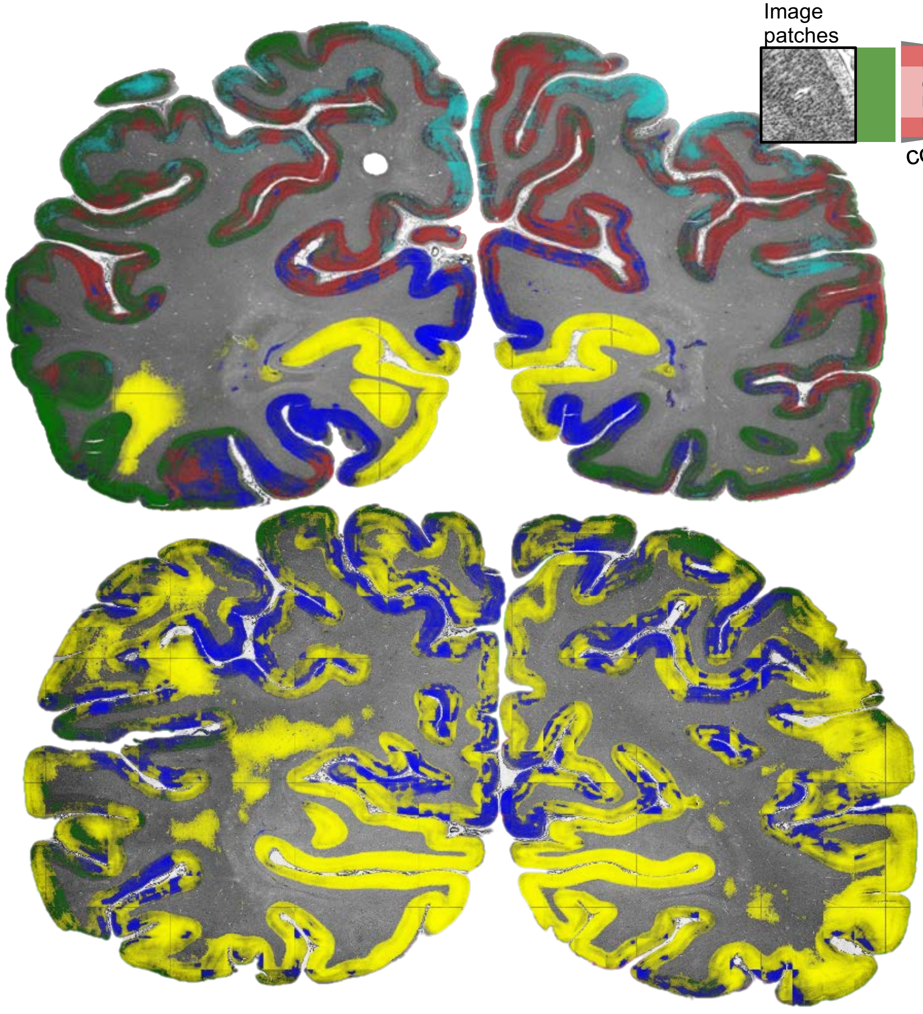


Which brain area is depicted?

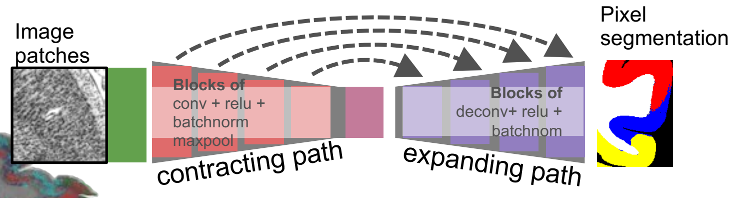
Fully supervised multi-area segmentation in the visual system using modified U-Nets (2016)



Expert (many hours per image)

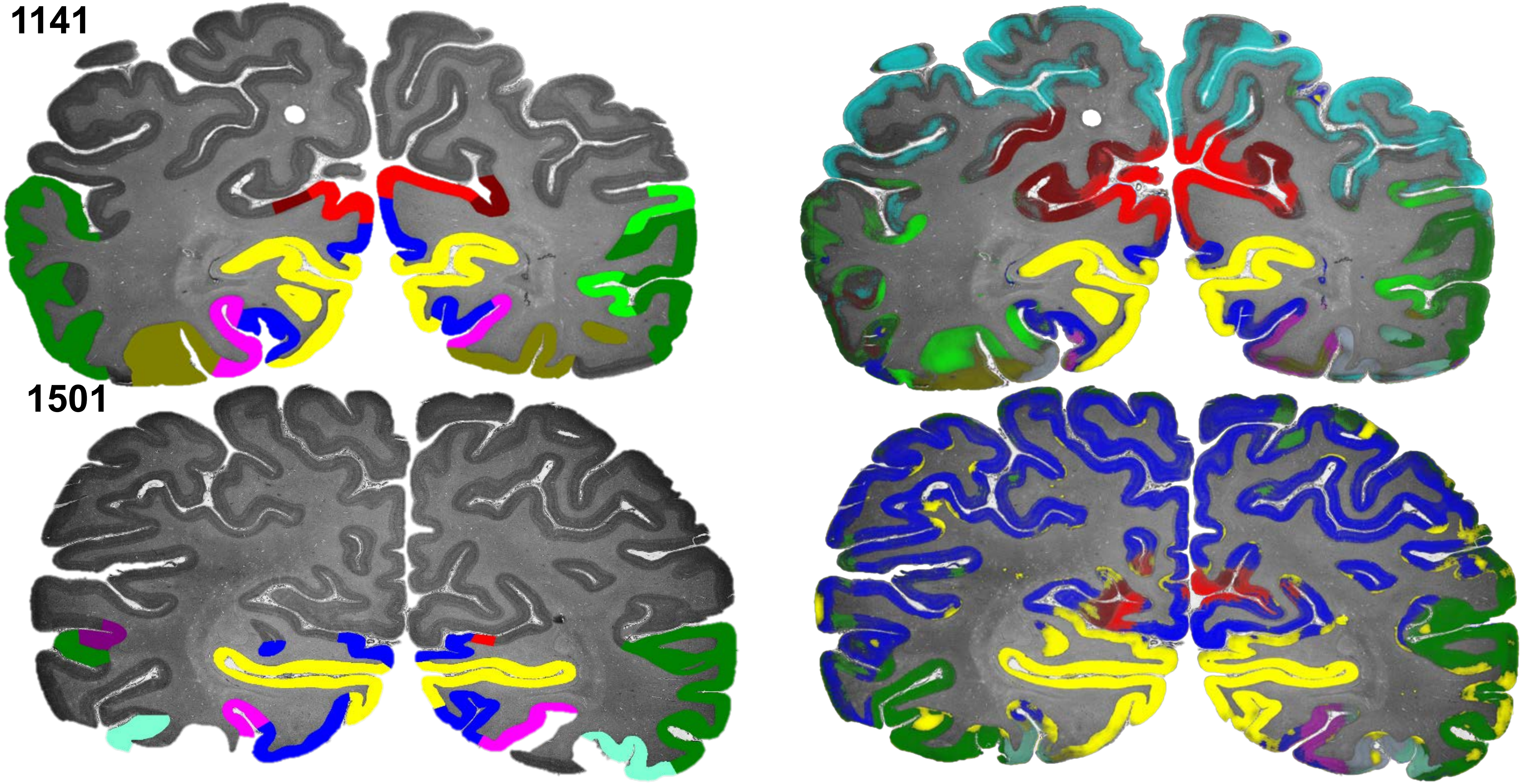


Deep Learning (few minutes)



Spitzer, Caspers, Amunts, Dickscheid et al.. **Feasibility of deep learning for automatic parcellation of cortical regions in histological sections**. OHBM 2016

Introducing a weak atlas prior for multi-area segmentation (2017)

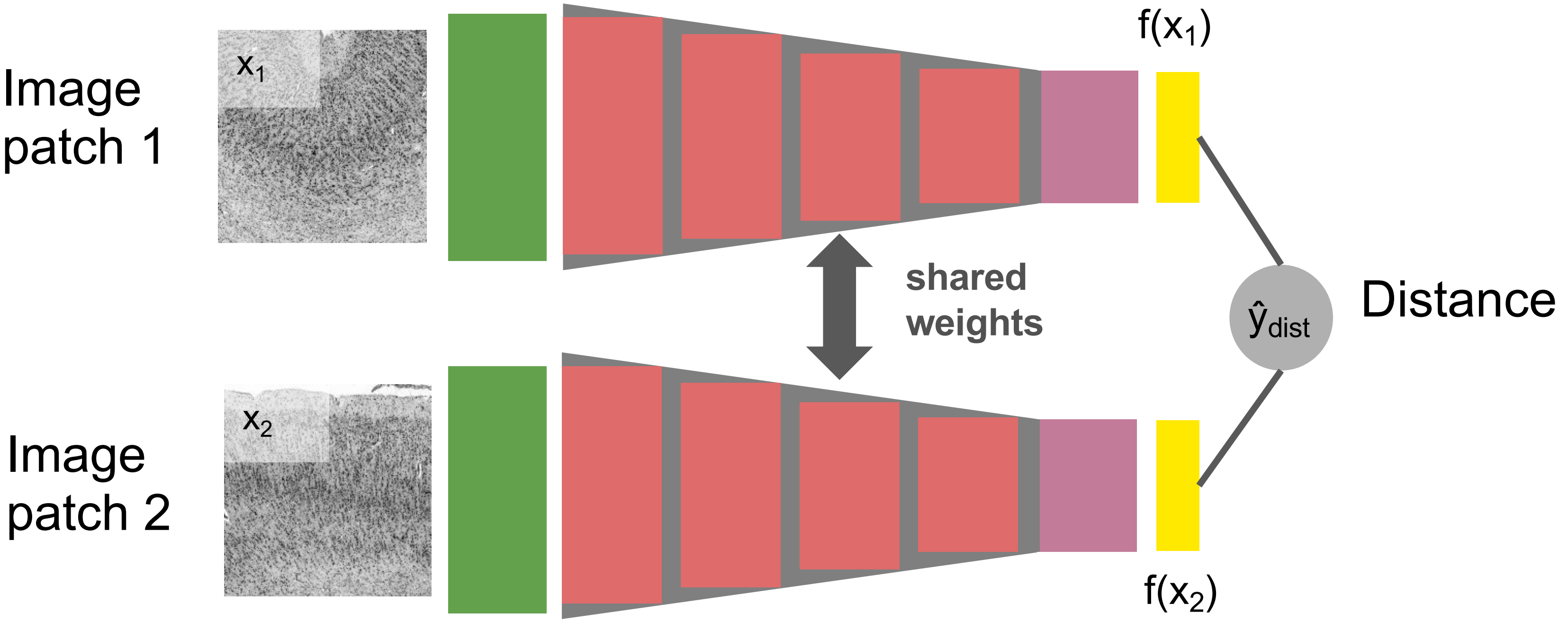


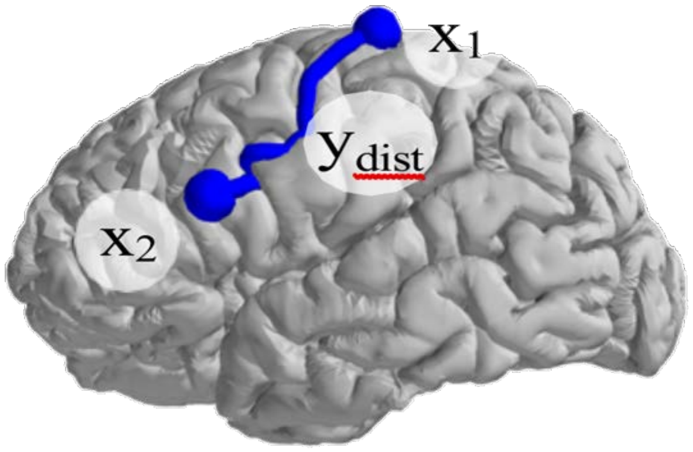
Expert (many hours per image)

Deep Learning (few minutes)

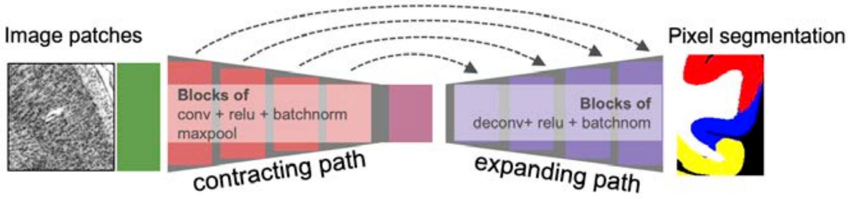
Spitzer, Amunts, Harmeling, Dickscheid. **Parcellation of visual cortex on high-resolution histological brain sections using convolutional neural networks.** ISBI 2017

Self-supervision: A siamese network predicts geodesic distance between pairs of image patches

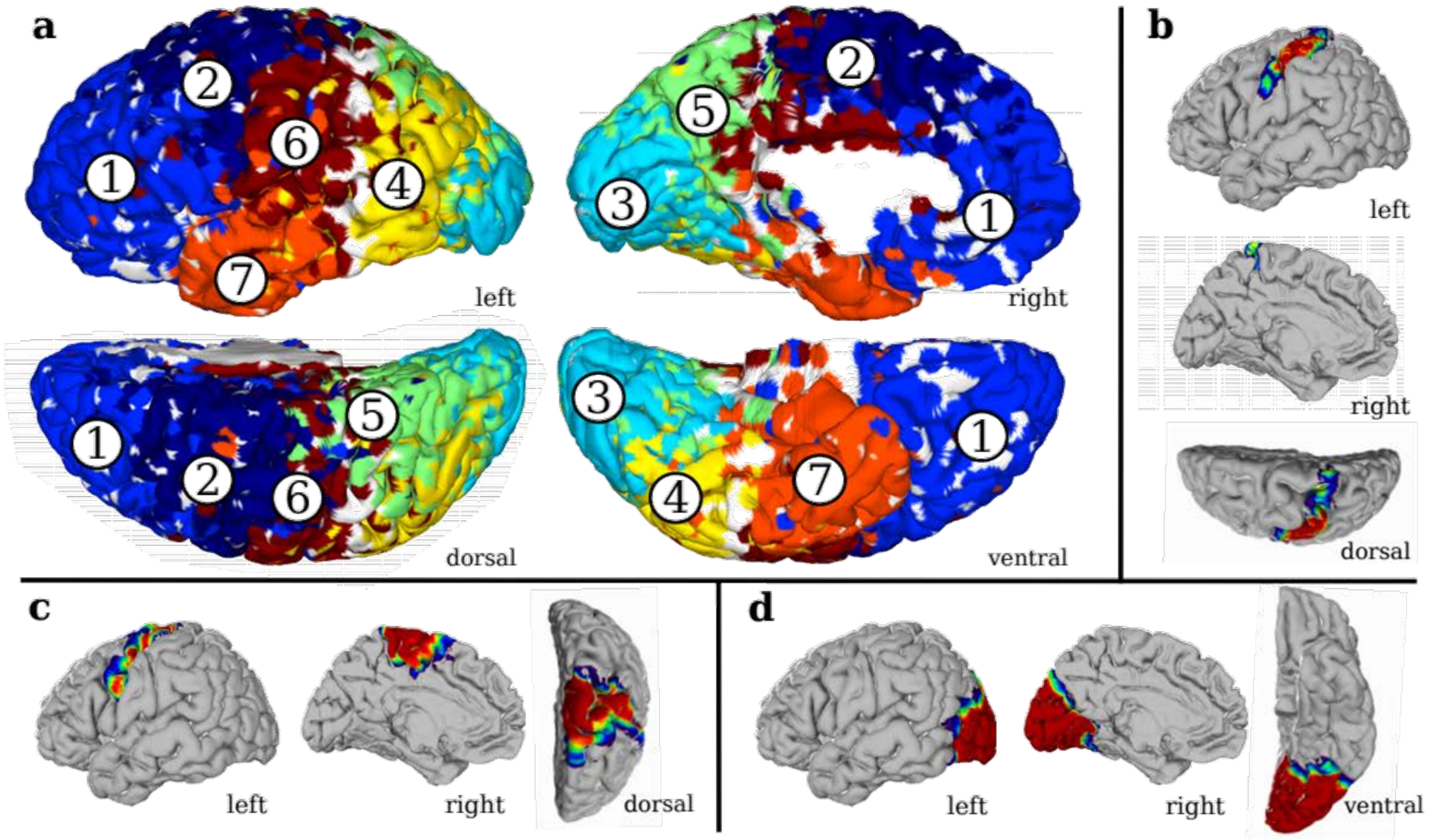




Spitzer, Kiwitz, Amunts, Harmeling, Dickscheid: Improving cytoarchitectonic segmentation of human brain areas with self-supervised siamese networks. MICCAI 2018



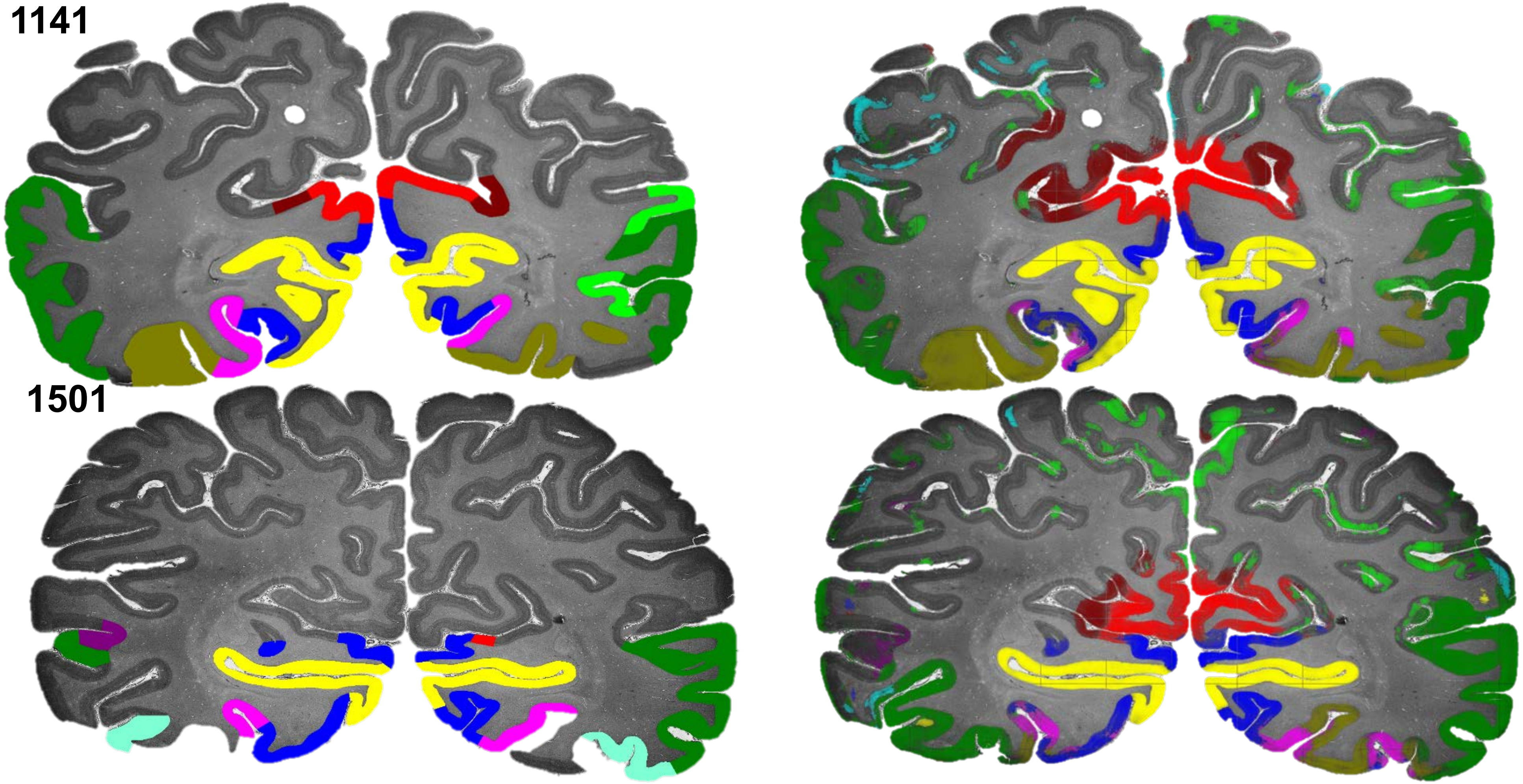
The CNNs learns a compact encoding of cytoarchitecture – more than border detection



Clustering of the latent features learned by the siamese network

Spitzer, Amunts, Harmeling, Dickscheid: Compact feature representations for human brain cytoarchitecture using self-supervised learning. MIDL 2018

Initializing multi-area segmentation from the self-supervised task (2018)



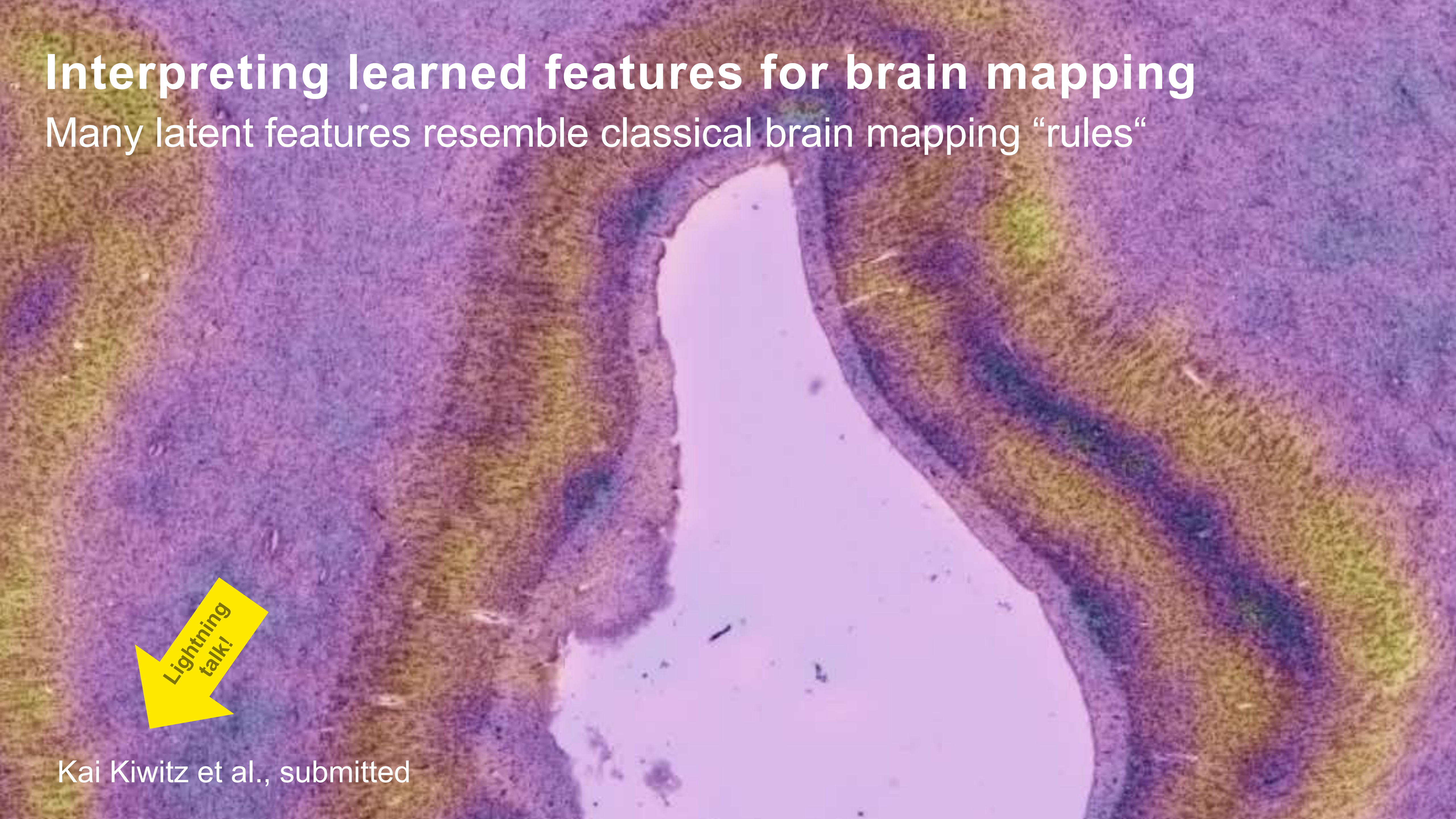
Expert (many hours per image)

Deep Learning (few minutes)

Spitzer, Kiwitz, Amunts, Harmeling, Dickscheid. **Improving cytoarchitectonic segmentation of human brain areas with self-supervised siamese networks.** MICCAI 2018

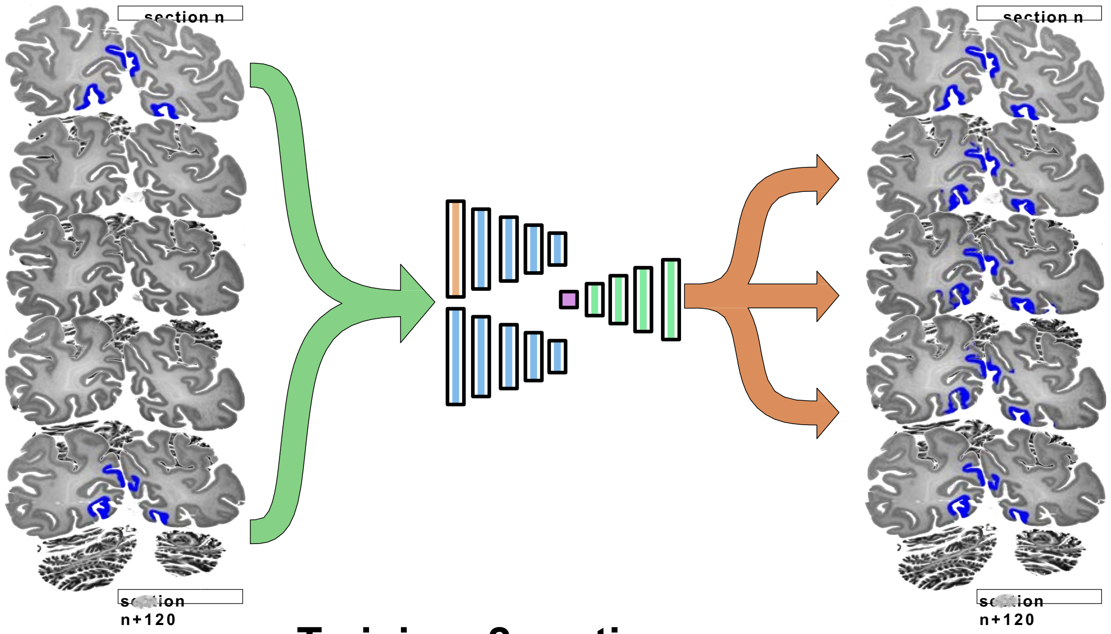
Interpreting learned features for brain mapping

Many latent features resemble classical brain mapping "rules"



Kai Kiwitz et al., submitted

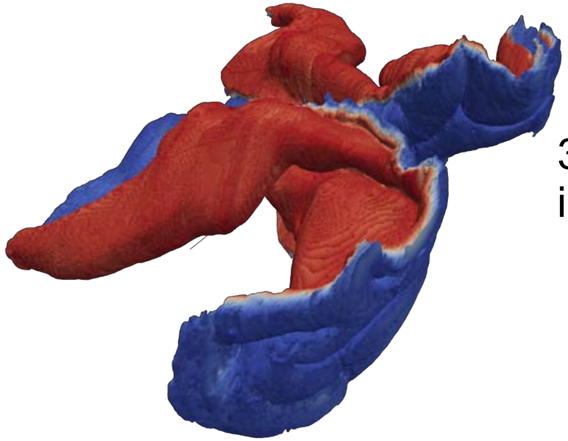
CNNs support the neuroanatomist:
Single-area segmentation across full serial stacks



Training: 2 sections

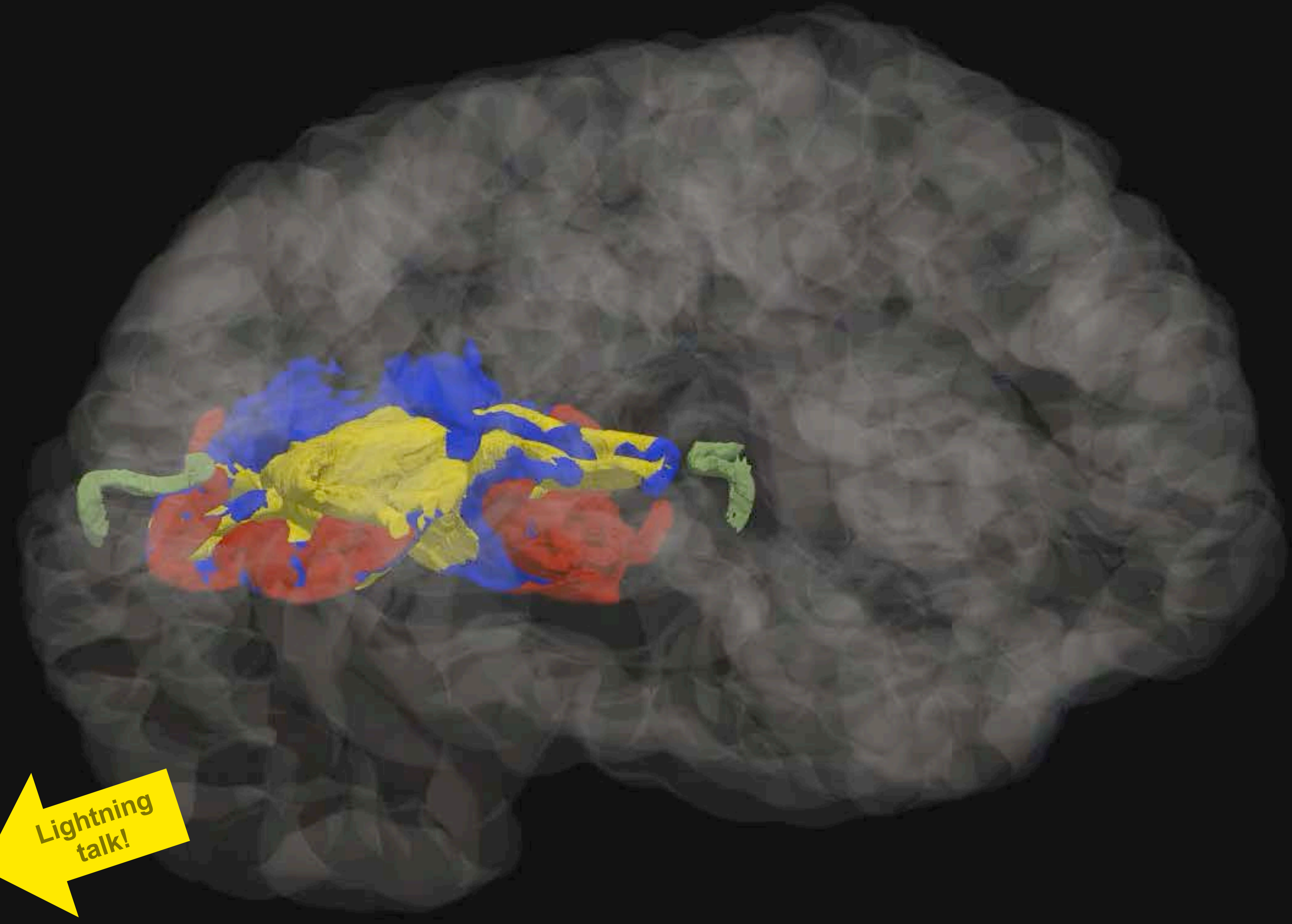
Inference: >100 sections in between

Area hOc1: ~2400 1 micron sections



3D reconstruction
in BigBrain space

Schiffer, Amunts, Dickscheid et al:. **Deep learning speeds up gapless cytoarchitectonic mapping in serial histological sections.** *OHBM 2019*



3D maps of areas hOc1, hOc2, hOc3v and hOc5
Based on precise 1 micron segmentations in ~2300 histological sections using Deep Learning

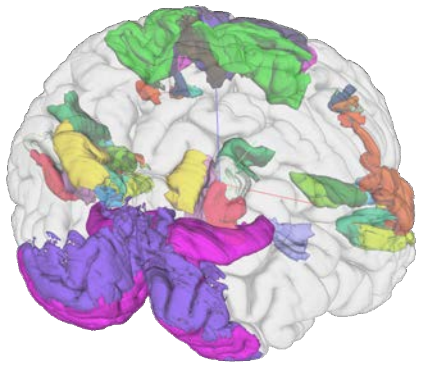
Christian Schiffer et al., in prep

Lightning talk!

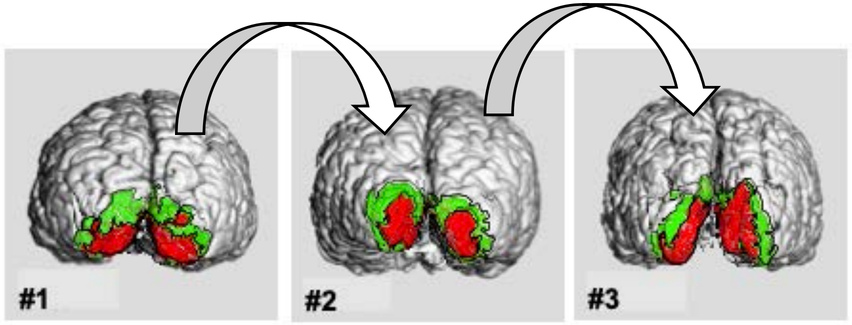
Where are we going from here?

Where are we going from here?

- Use the single-area CNN as a tool to map more areas in BigBrain



- Transfer learning - propagate maps from BigBrain to a new brain sample, overcoming biological variability and different imaging devices



- Develop learning strategies to build a general (interpretable?) multi-area segmentation model for the whole brain

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Blake Richards
Paule-J Toussaint

Thank You