

Detailed laminar characteristics of the human neocortex revealed by NODDI and histology

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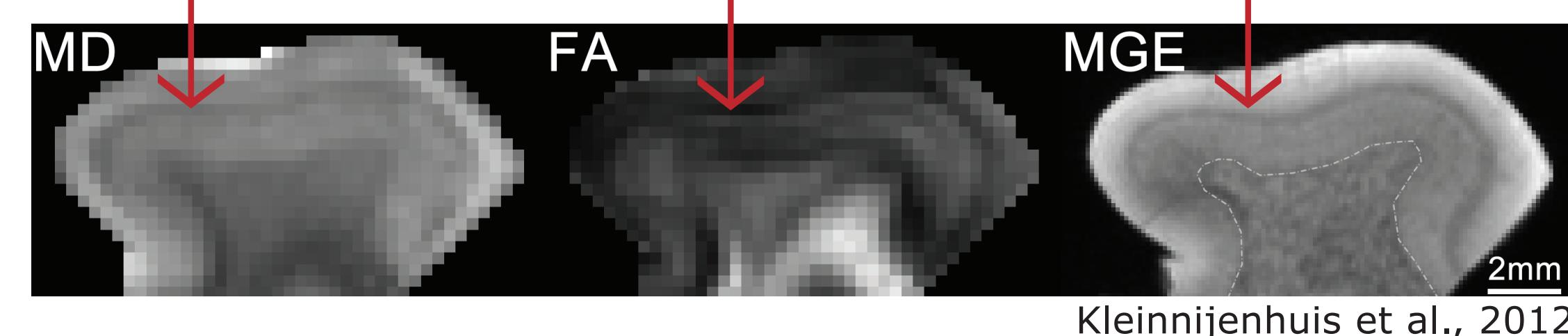
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Introduction

Diffusion weighted imaging (**DWI**) has the potential to provide a rich noninvasive description of **cortical architecture**.

Diffusion properties of the primary visual cortex (**V1**) are **layer-specific**¹.

In particular, the stria of Gennari displays low diffusivity and anisotropy.

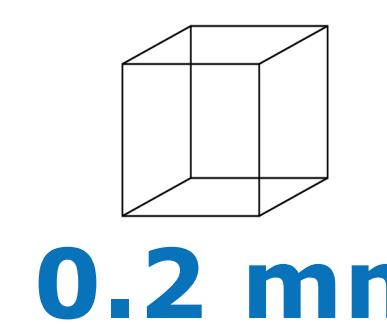
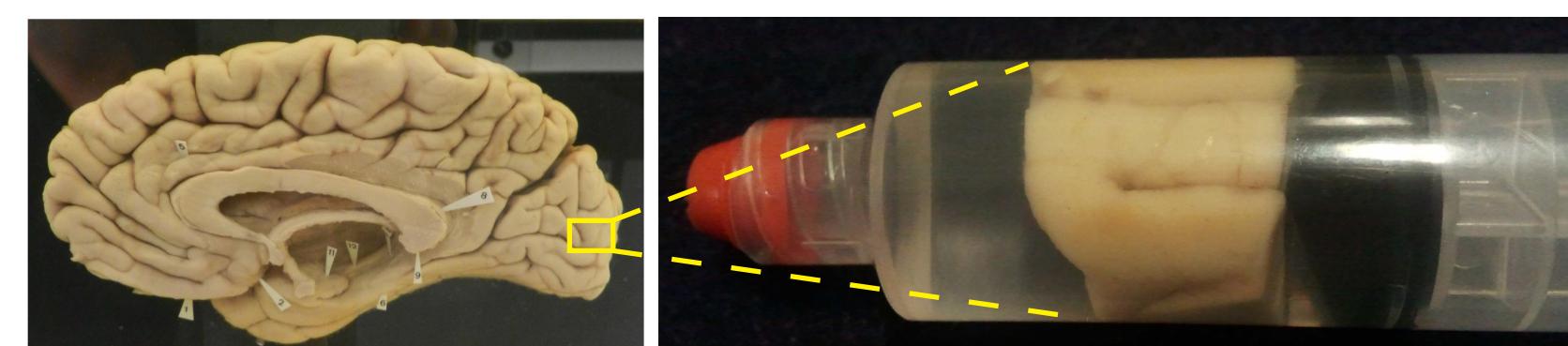


Here, we extend these findings by fitting the **NODDI tissue model**² to **multi-shell DWI** data and compare the results to **histology**.

Acquisition

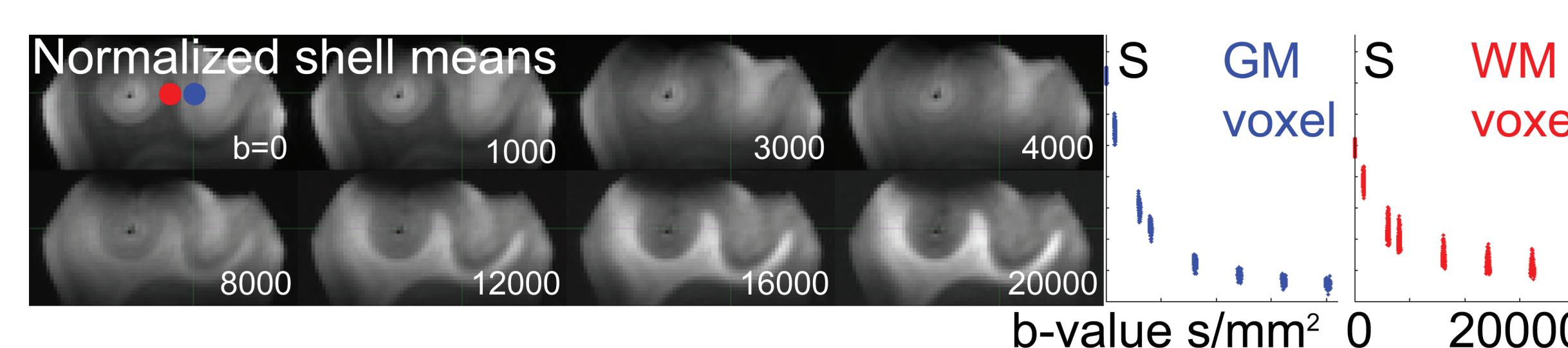
Samples: Human V1

Human brain tissue samples of primary visual cortex (V1) including underlying white matter.



Diffusion Weighted Imaging

- 9.4T Bruker BioSpec; $G_{\max} = 660 \text{ mT/m}$
- **cryogenic** mouse brain **coil** (20-30 K)
- PGSE w segmented EPI readout: TR/TE=6750/26 ms
- **8 shells x 384/54 directions** (sample A/sample B)
 - $b=[0 \text{ } 1000 \text{ } 3000 \text{ } 4000 \text{ } 8000 \text{ } 12000 \text{ } 16000 \text{ } 20000] \text{ s/mm}^2$
 - $\delta/\Delta = 8/12 \text{ ms}$

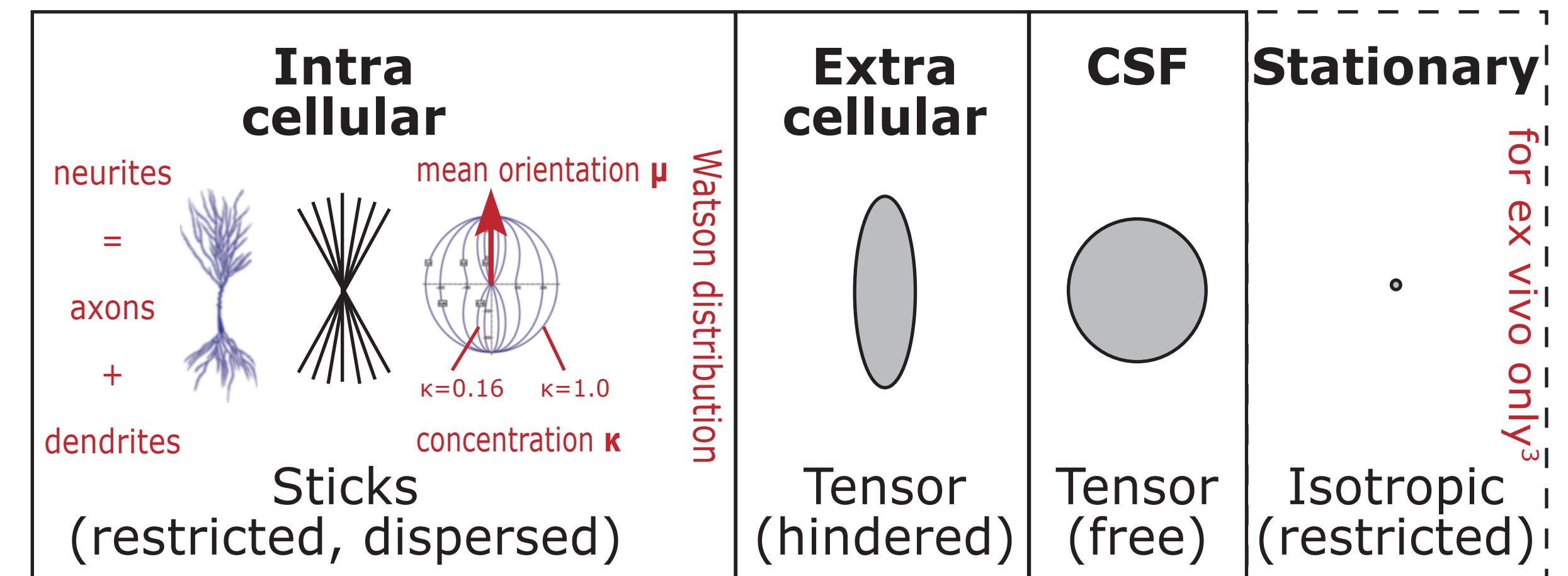


Histology:

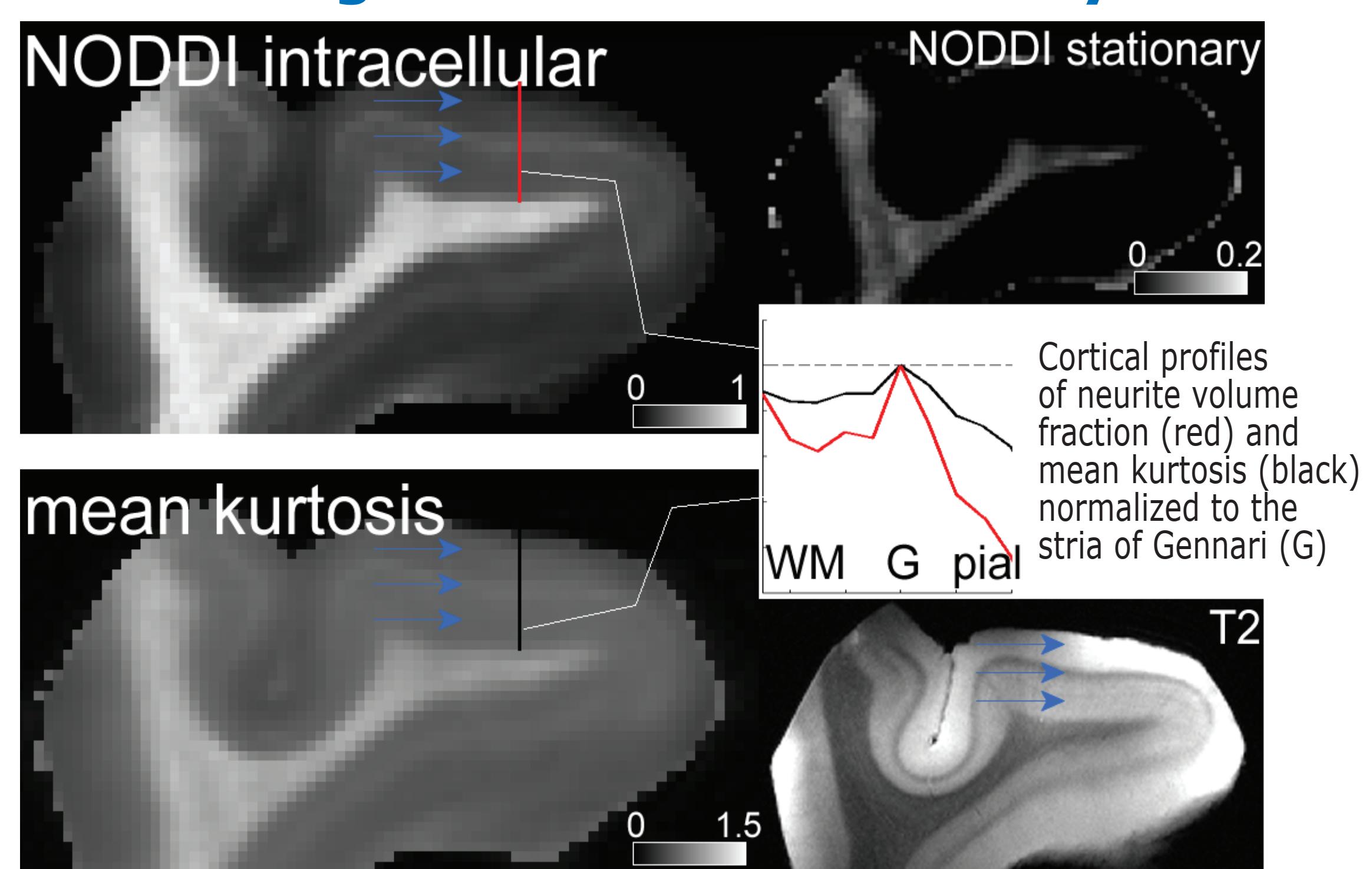
- **Luxol Fast Blue** (myelin)
- **Bodian** (axons)
- Hematoxylin & Eosin (**H&E**) (cell bodies)
- Virtual slices at **20X** magnification

Neurite Orientation Dispersion and Density Imaging²

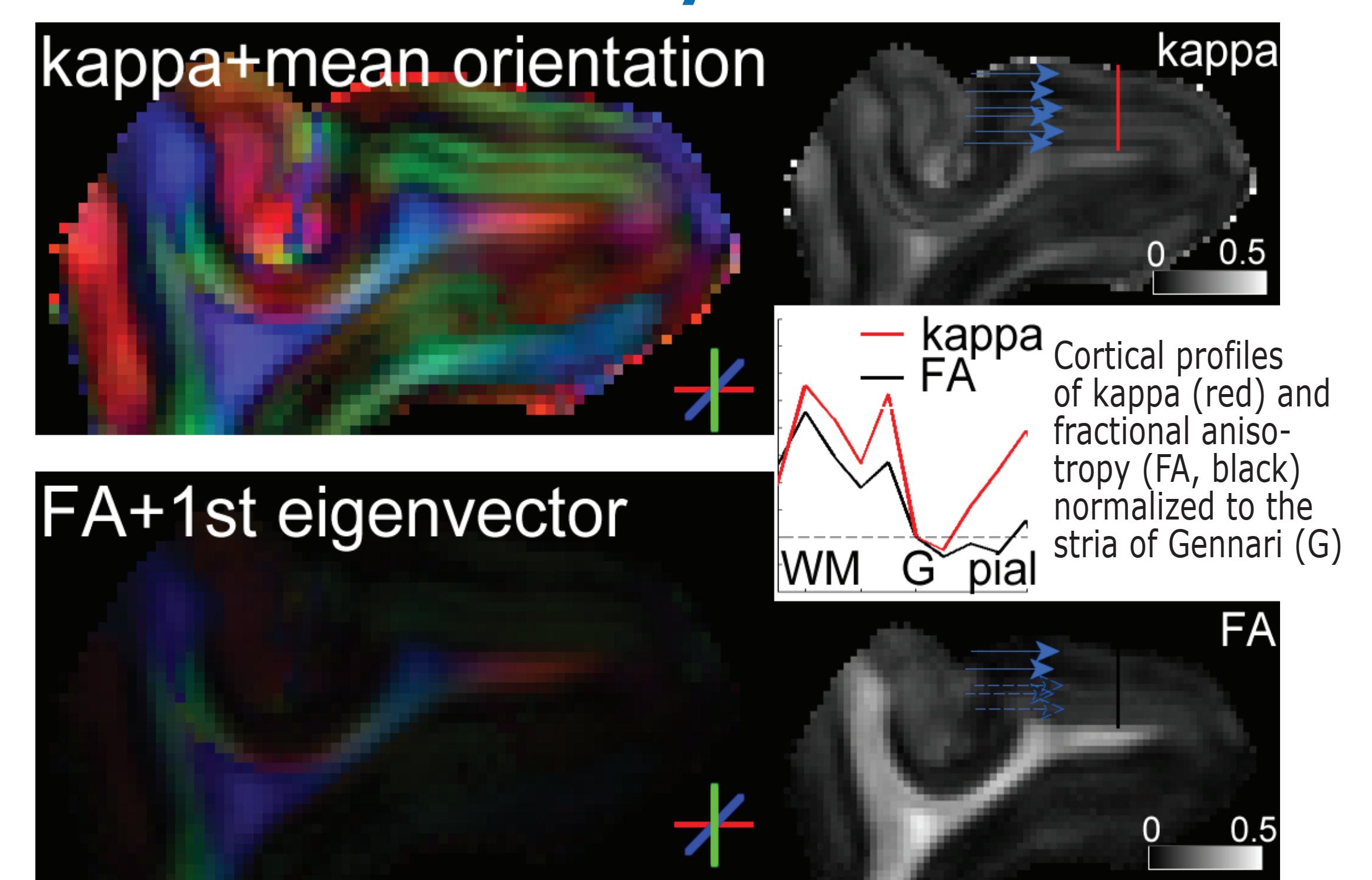
Multicompartment tissue diffusion model



Result 1: neurite volume fraction --> high contrast between layers

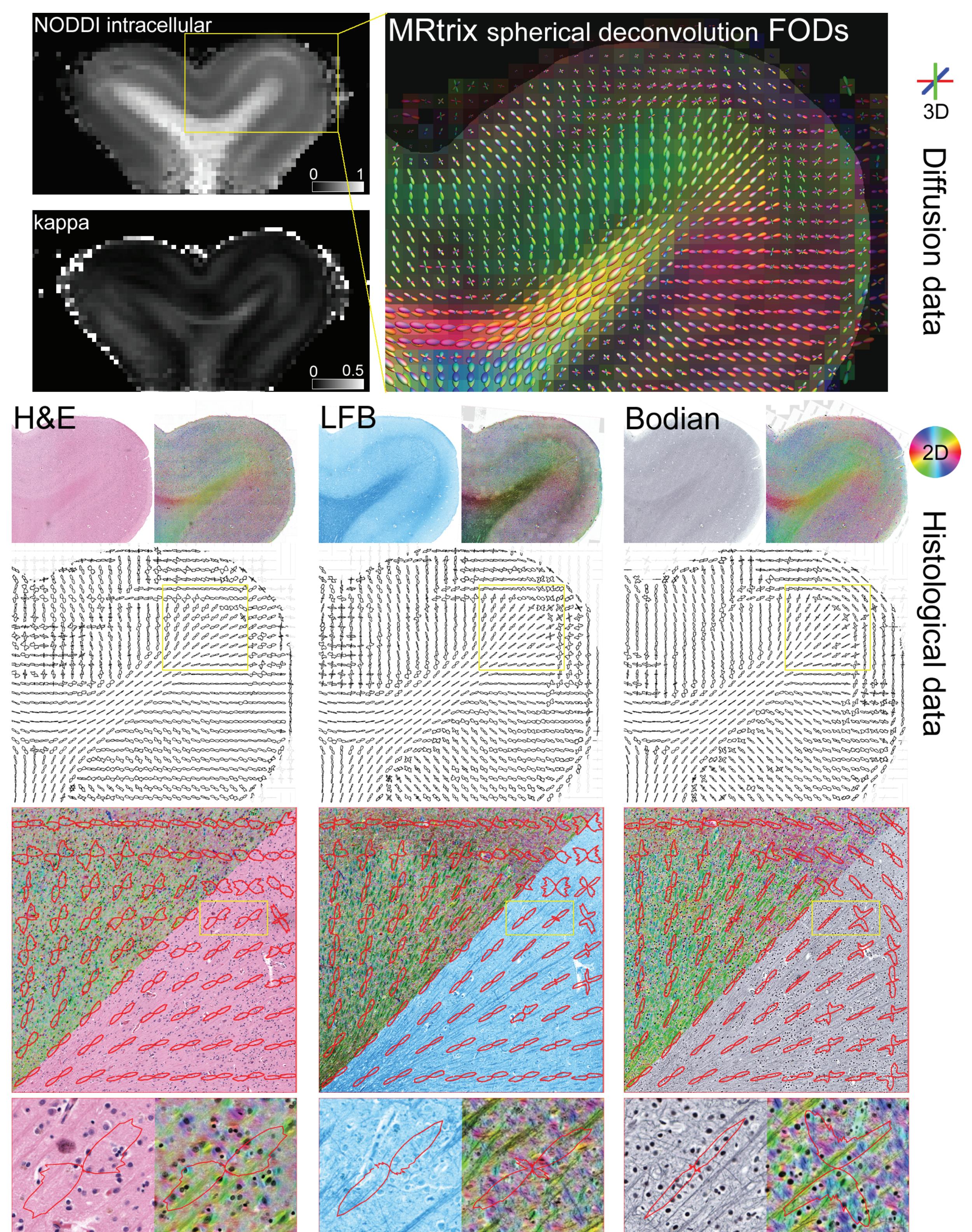


Result 2: orientation dispersion --> additional layers resolved



Structure Tensor Histology⁴

Orientation analysis of fibre stains



Discussion and Conclusion

The NODDI volume fractions allow **better discrimination of cortical layers** as their standard alternative (kurtosis).

The cortical neurite orientation dispersion profile shows a **fine-grained division in architectural layers**, with more laminae as compared to volume fractions and ultra high resolution T2.

Although for *ex vivo* DWI extensive scan time and superb gradient performance are desirable, NODDI does not require this²: ***in vivo* cortical investigations are clinically feasible**.