



Donders Institute
for Brain, Cognition and Behaviour



Salt Lake City, Utah, USA
20-26 April 2013
"Discovery, Innovation & Application – Advancing MR for Improved Health"

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Detailed laminar characteristics of the human neocortex revealed by NODDI

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Declaration of Relevant Financial Interests or Relationships

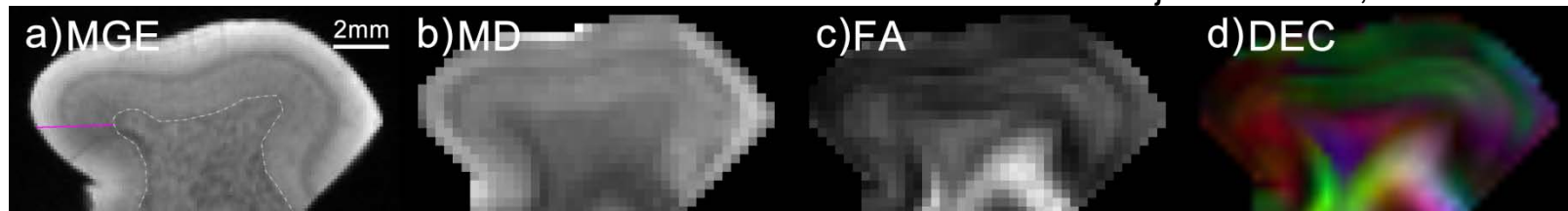
Speaker Name: Michiel Kleinnijenhuis

I have no relevant financial interest or relationship to disclose with regard to the subject matter of this presentation.

Towards in vivo cortical architecture

- Diffusion can be used as structural probe
- Tensor metrics vary over cortical layers

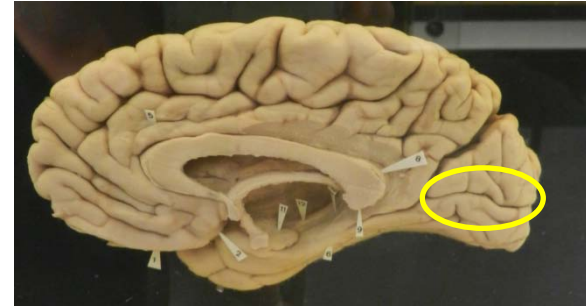
Kleinnijenhuis et al., Cortex 2012



- Extension to multishell

Samples

- post-mortem interval (< 24 h)
- fixed in formalin (> 1 month)
- 1 cm³ calcarine sulcus (V1)
- soaked in phosphate buffered saline (> 72 h)
- scanned in proton-free liquid



Diffusion Weighted Imaging

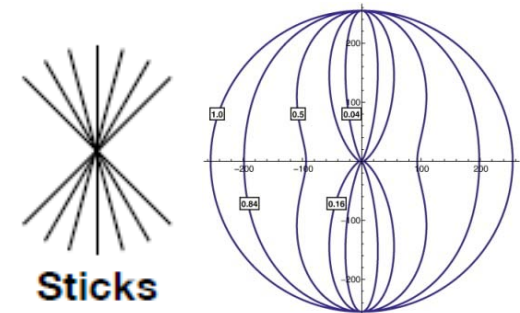
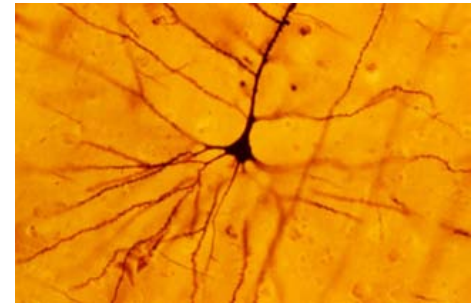
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- System:
 - 9.4T Bruker BioSpec; $G_{\max} = 660 \text{ mT/m}$
 - cryogenic mouse brain coil (20-30 K)
- PGSE with segmented EPI readout
- $TR/TE = 6750/26 \text{ ms}$
- 0.2 mm isotropic voxels
- 8 shells x 384 (sample A) / 54 directions (sample B)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



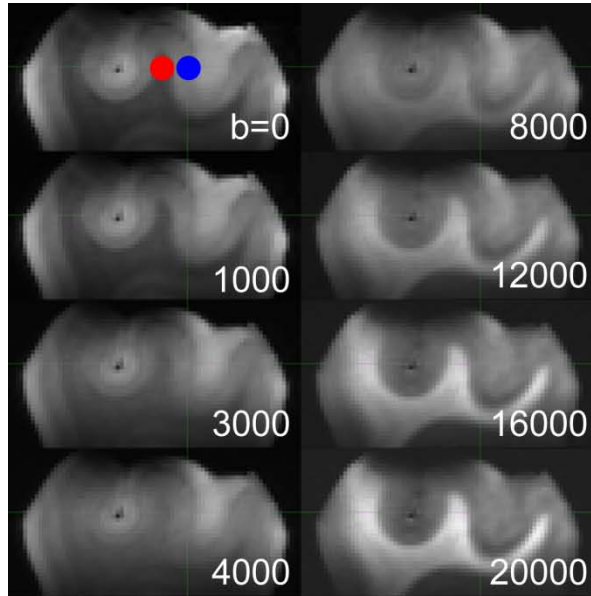
Neurite Orientation Dispersion and Density Imaging

- NODDI multicompartment tissue model (Zhang et al., NI 2012)
 1. neurite volume fraction
 2. extra-cellular volume fraction
 3. isotropic volume fraction
 4. isotropic restriction compartment
 - ➔ ex vivo only (Alexander et al, 2010)
- Watson distribution
 - ➔ mean orientation μ and concentration κ
 - ➔ modeling WM & GM

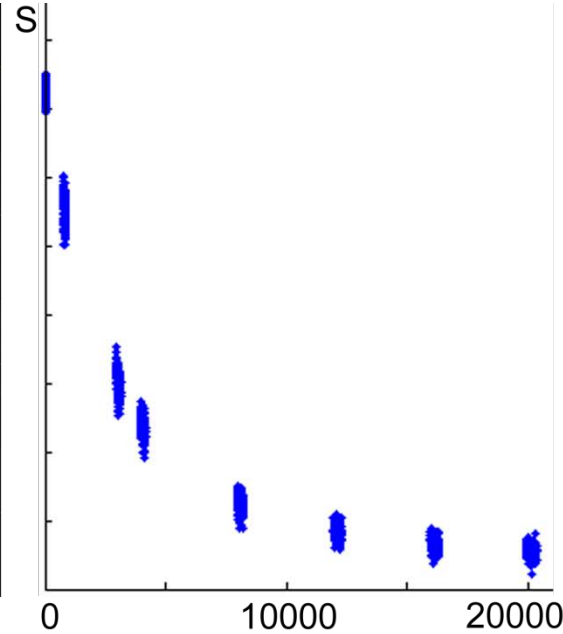


Data impression

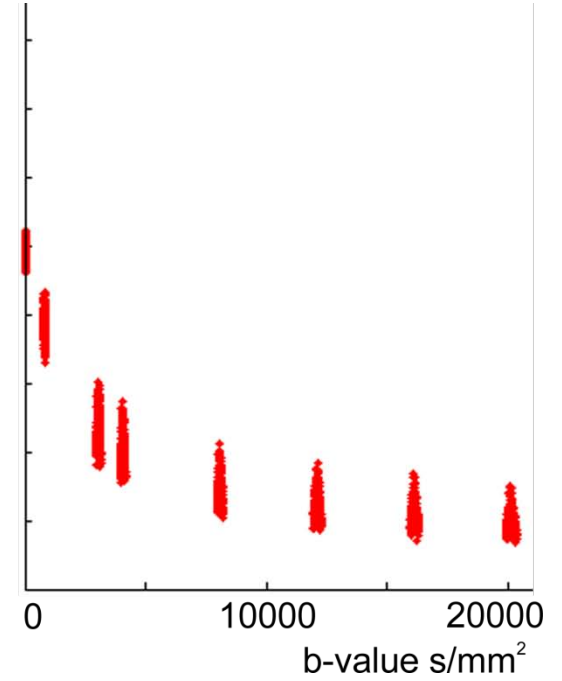
Normalized shell means



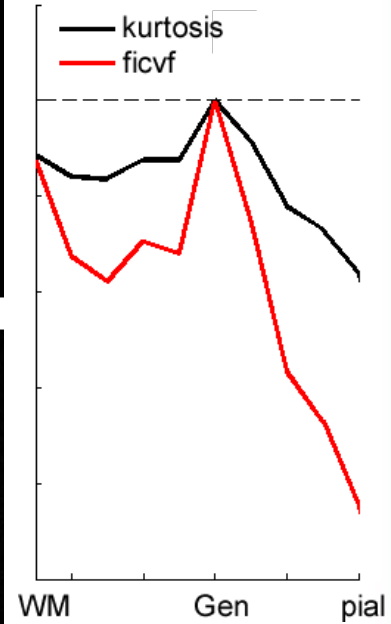
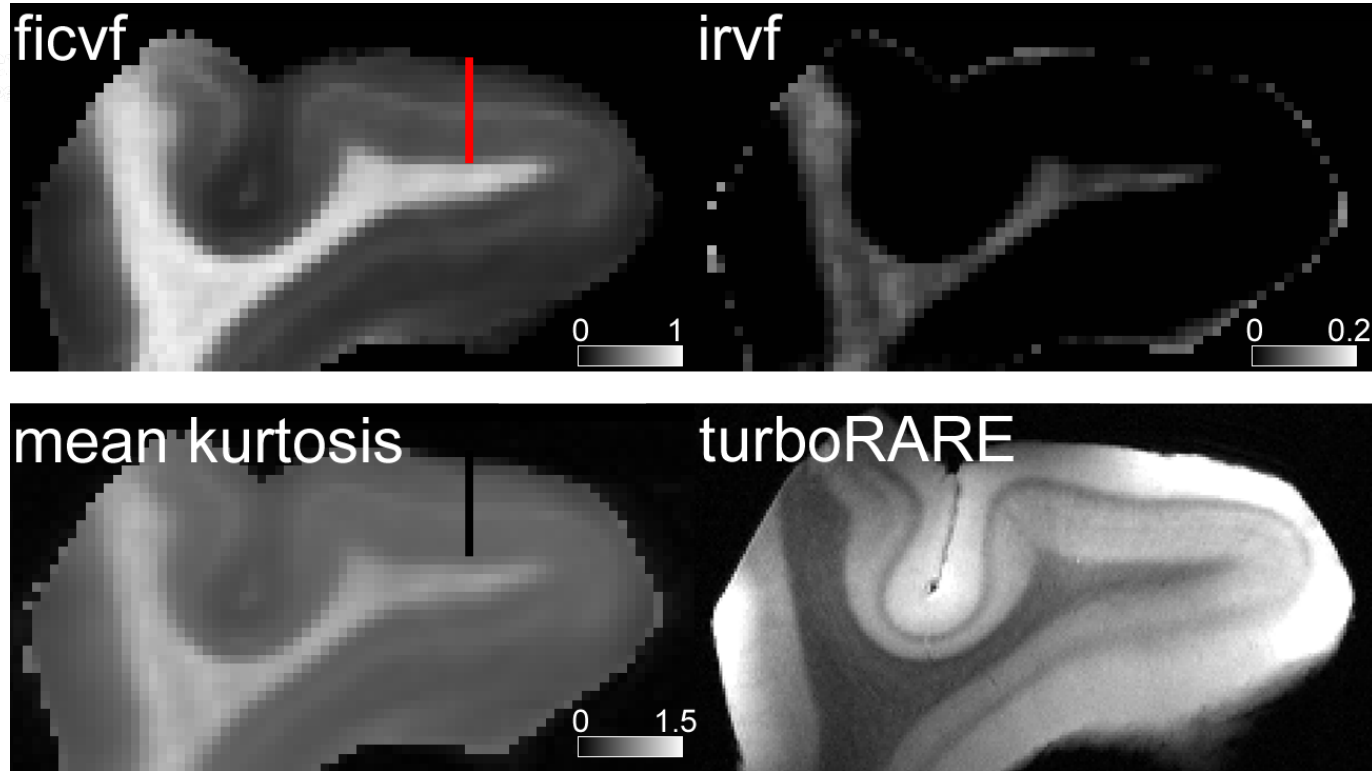
GM voxel



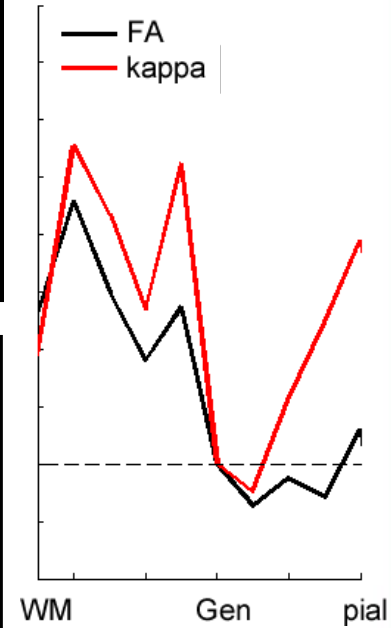
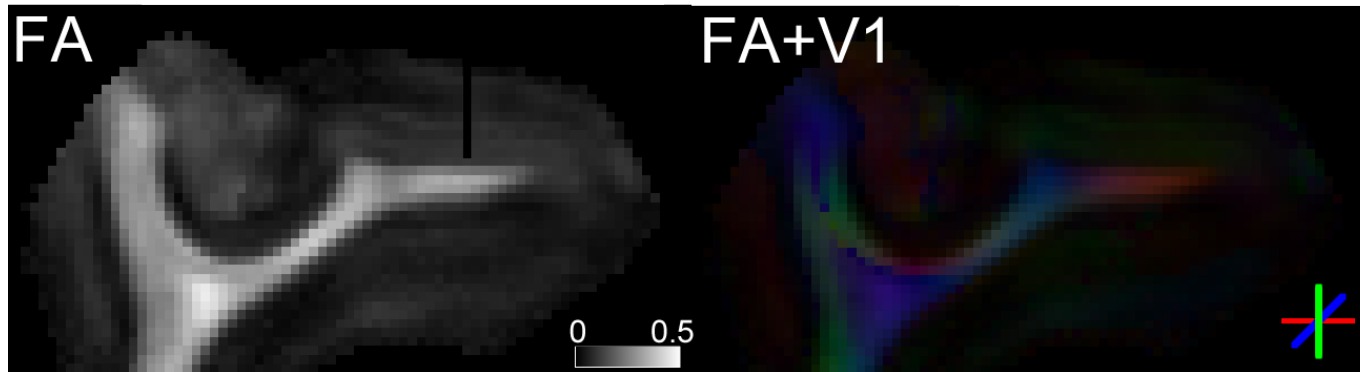
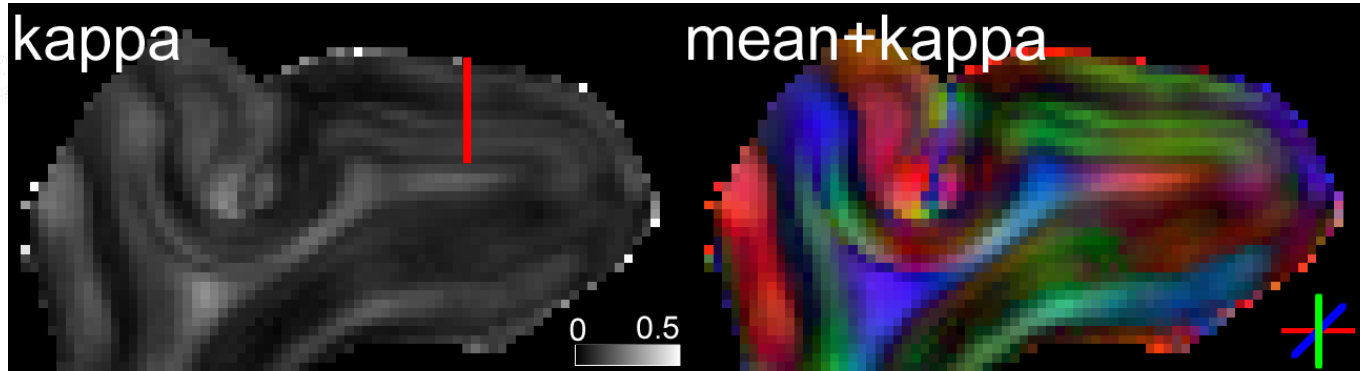
WM voxel



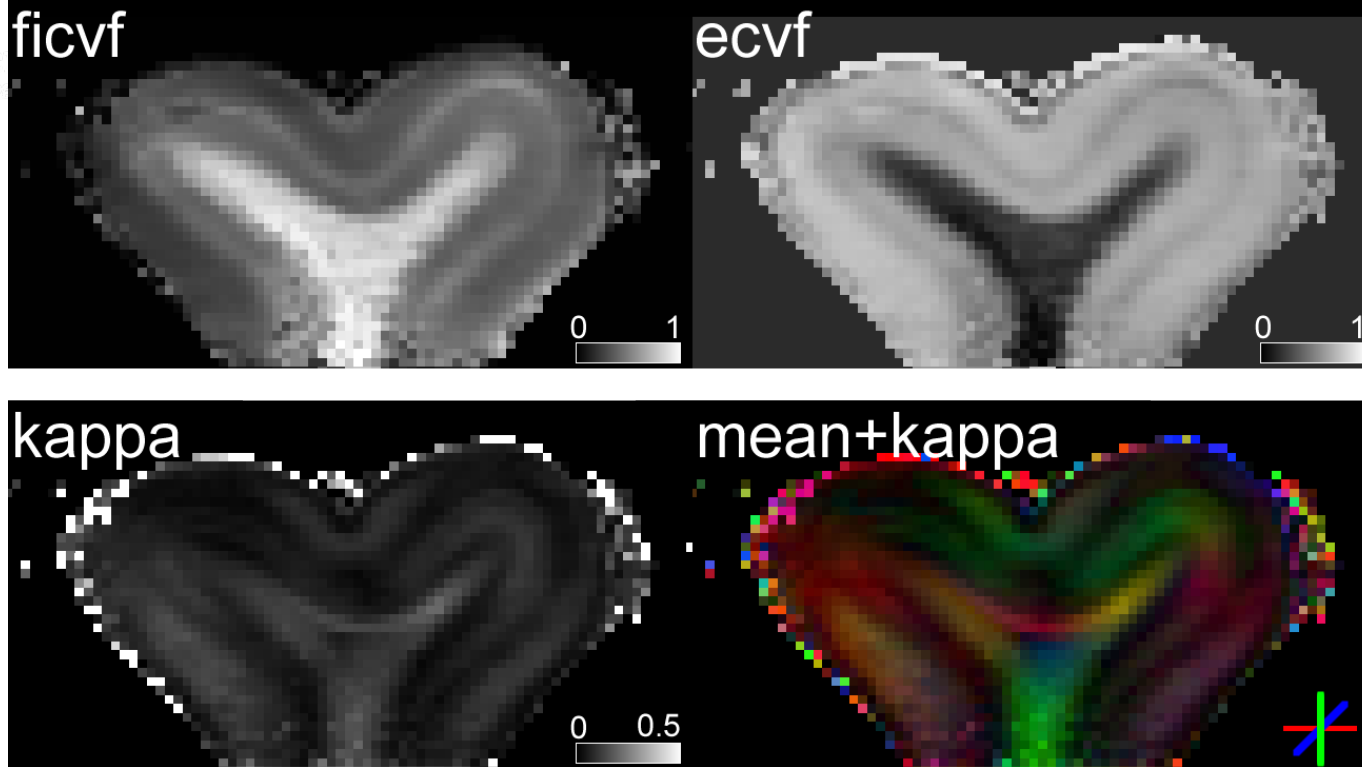
Volume fractions



Orientation dispersion



Sample B (54 directions)



Conclusions

- High layer discriminability
- Sharp delineation of layer boundaries in GM and WM
- Interpretable measures
- Cortical *in vivo* investigations feasible in clinical scan times



Thank you

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Dirk Ruiter

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DCCN: Markus Barth

Marcel Zwiers

VIP Brain Networks

MIRA

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Discussion

- Cortical *in vivo* investigations feasible in clinical scan times?
 - The number of directions can be limited
 - *In vivo* eliminates the need for $b=20000$
 - CRLB optimization¹ suggests 4 shells: $b=[0 \ 1000 \ 4000 \ 12000]$
 - Equates to $b=[0 \ 300 \ 1000 \ 3000]$ *in vivo*
- Neurite dispersion might vary with cortical curvature