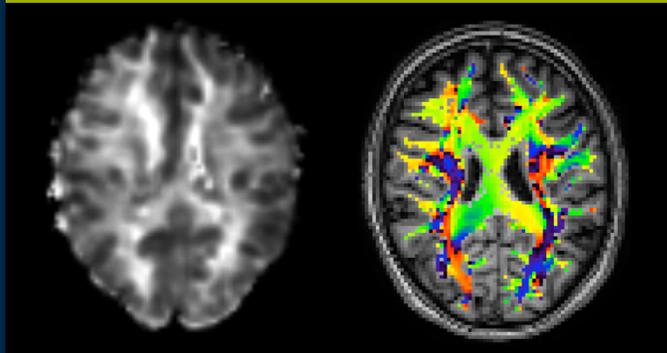


502

Assessment of white matter anisotropy effects in mq-BOLD based mapping of relative Oxygen Extraction Fraction

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Claus Zimmer¹, Fahmeed Hyder³, Christine Preibisch^{1,2,6}

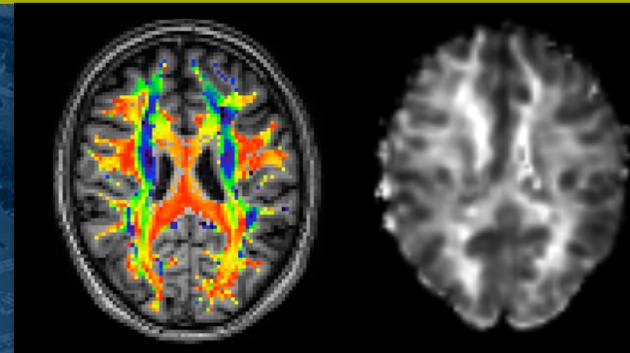


Session: **Perfusion & Permeability**

Room: **S04**

Time: **1:45 pm – 3:45 pm**

Date: **Tuesday, June 19, 2018**



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Declaration of Financial Interests or Relationships

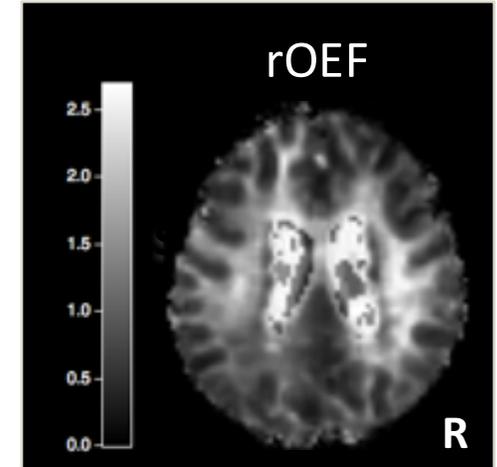
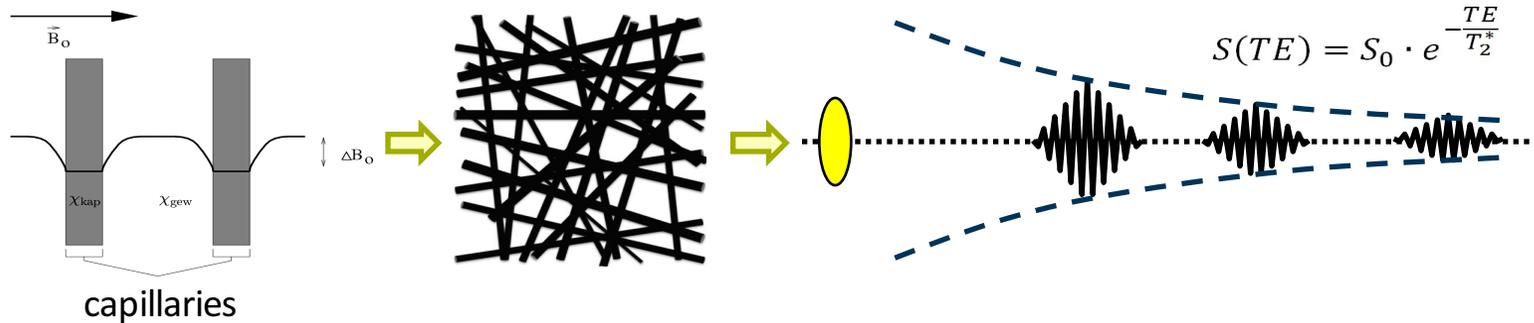
Speaker Name: Stephan Kaczmarz

I have no financial interests or relationships to disclose with regard to the subject matter of this presentation.

Background

Oxygen Extraction Fraction (OEF): Fundamental marker of cerebral metabolic function

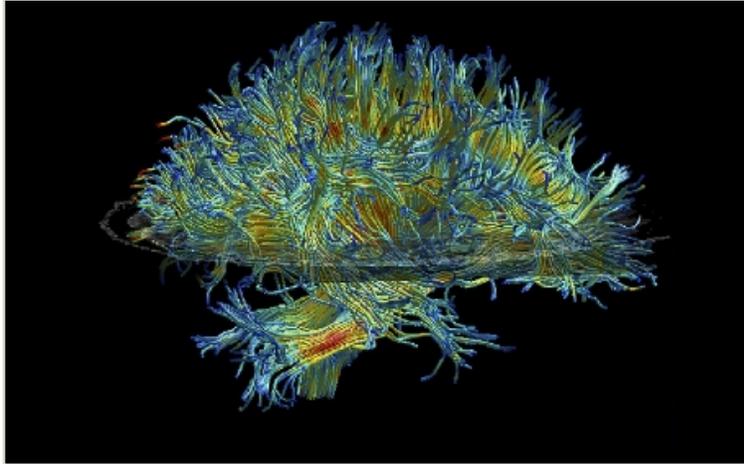
- Measurement by **multi-parametric quantitative BOLD** (mq-BOLD)
- Model vasculature by randomly oriented cylinders with infinite length
- Three separate measurements of T_2^* , T_2 and rCBV by DSC



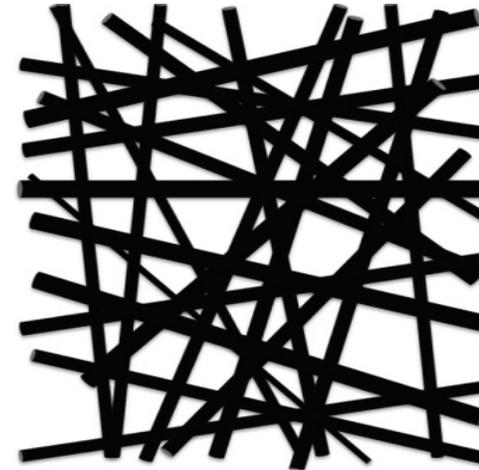
$$rOEF = \frac{R'_2}{c \cdot rCBV} \quad \text{with} \quad R'_2 = \frac{1}{T_2^*} - \frac{1}{T_2}$$

rCBV: relative cerebral blood volume
 $c = 4/3 \cdot \gamma \cdot \pi \cdot \Delta\chi \cdot B_0 \approx 317 \text{ Hz @3T}$

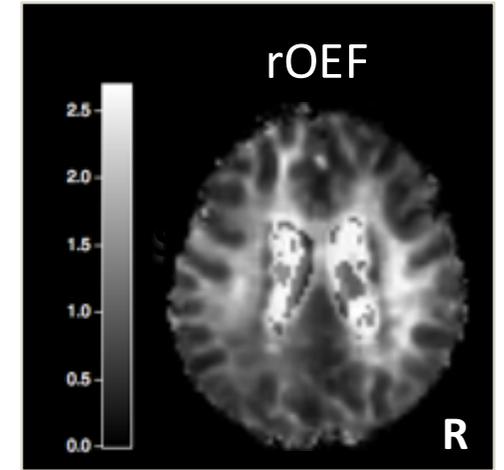
Motivation



Highly ordered WM



mq-BOLD model



mq-BOLD derived map

Highly ordered WM fiber structure

Preferential blood vessel alignment

Orientation effects in GRE & DSC

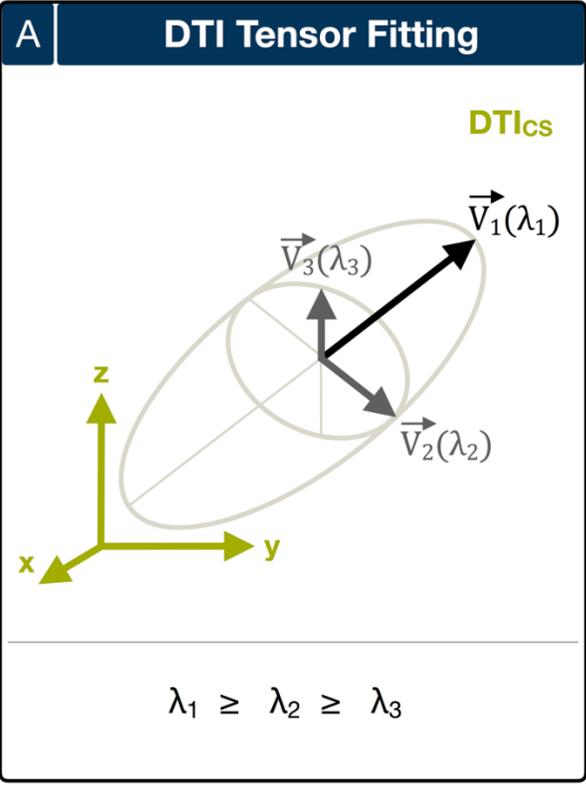
rOEF anisotropy effects?



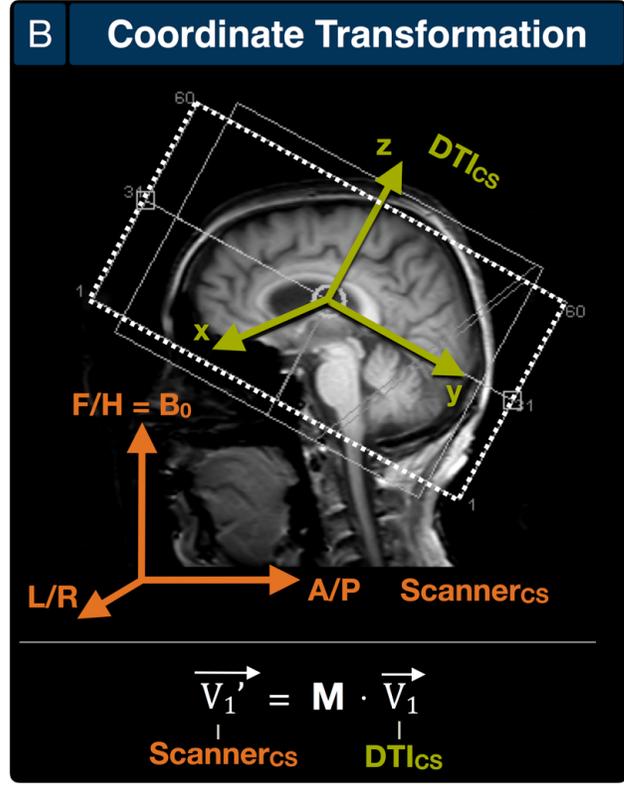
Analyze validity of mq-BOLD derived rOEF with respect to orientation effects

Material & Methods

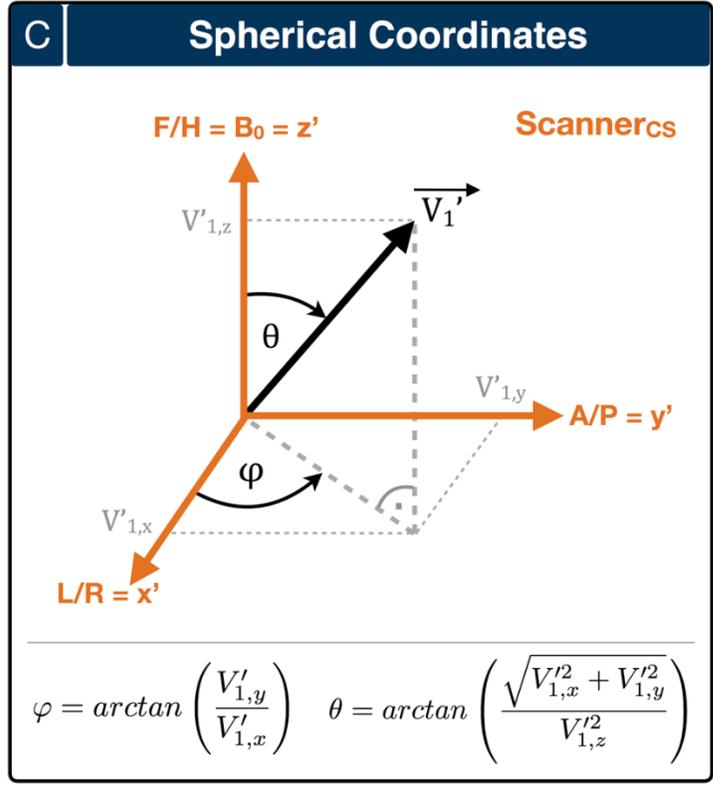
DTI fiber orientation information



Get main fiber direction



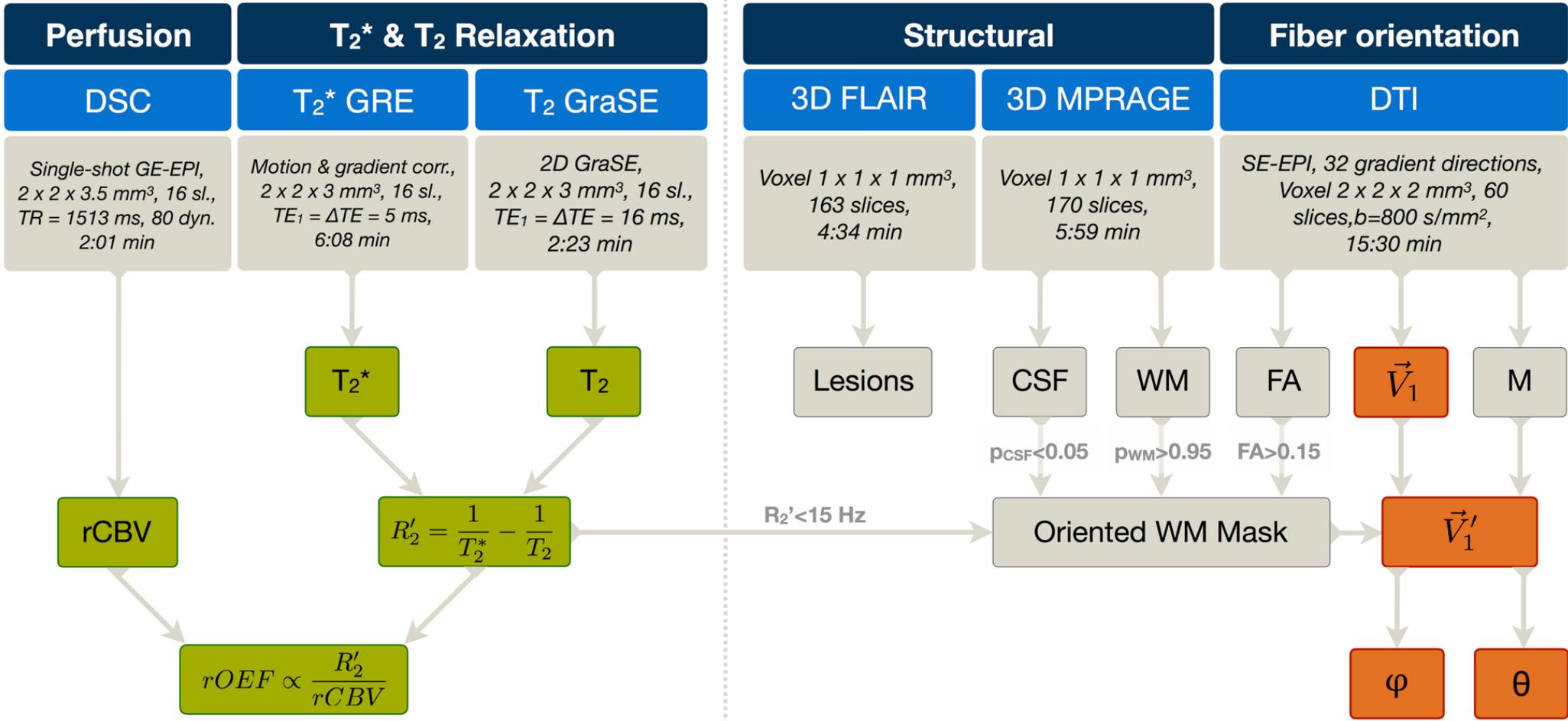
Rotate vector



Calculate spherical angles

Material & Methods

MR imaging protocol



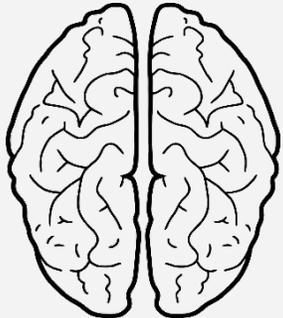
Material & Methods

Scanner & Participants



- 3T Philips Ingenia
- Software release 5.1.8
- 16 channel head-neck coil
- Custom patches

30 HC

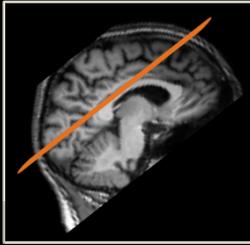


- No previous strokes or lesions
- No MR contraindications
- No kidney disease

70.3 ± 4.8 y

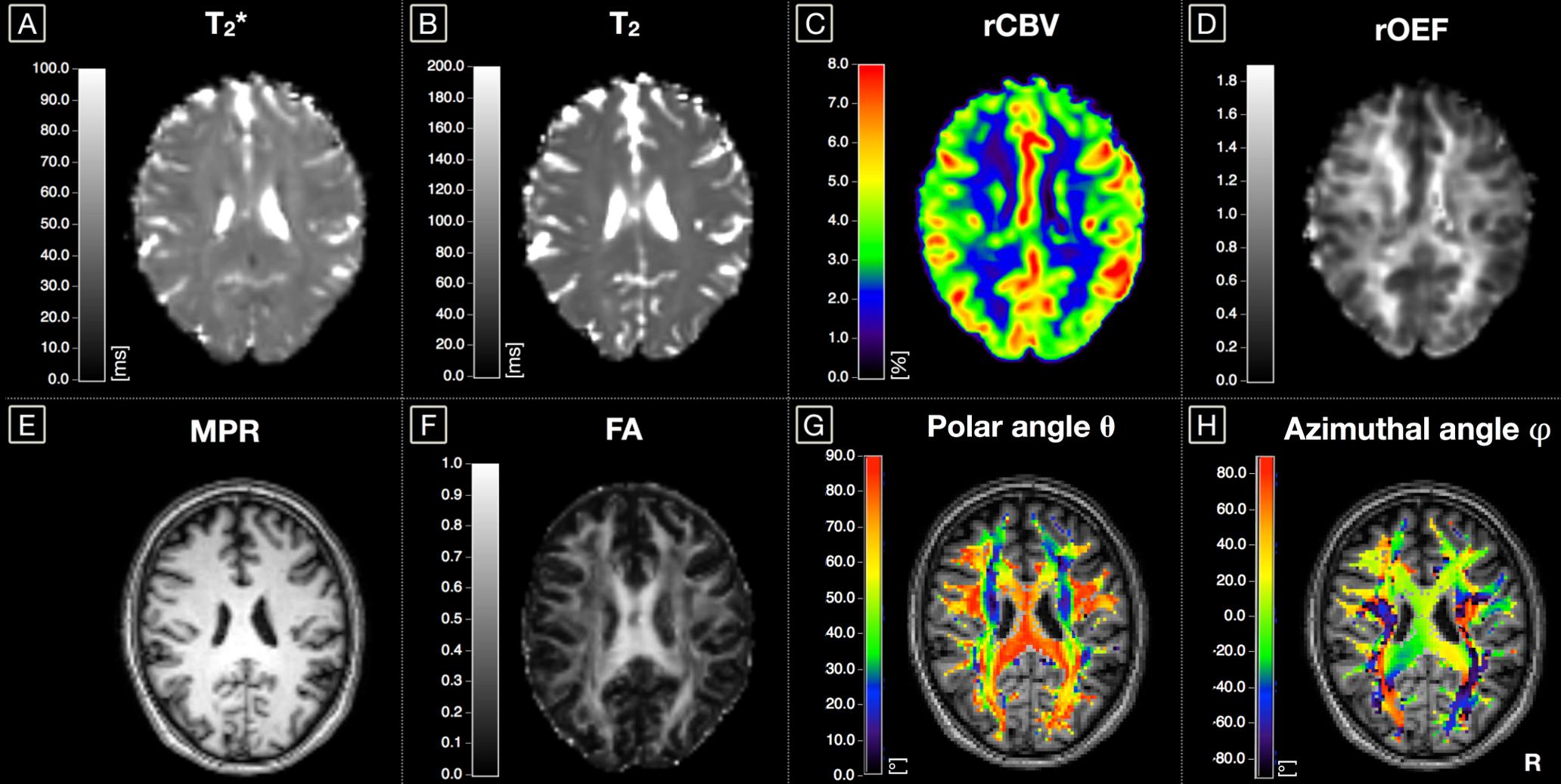


65y, male



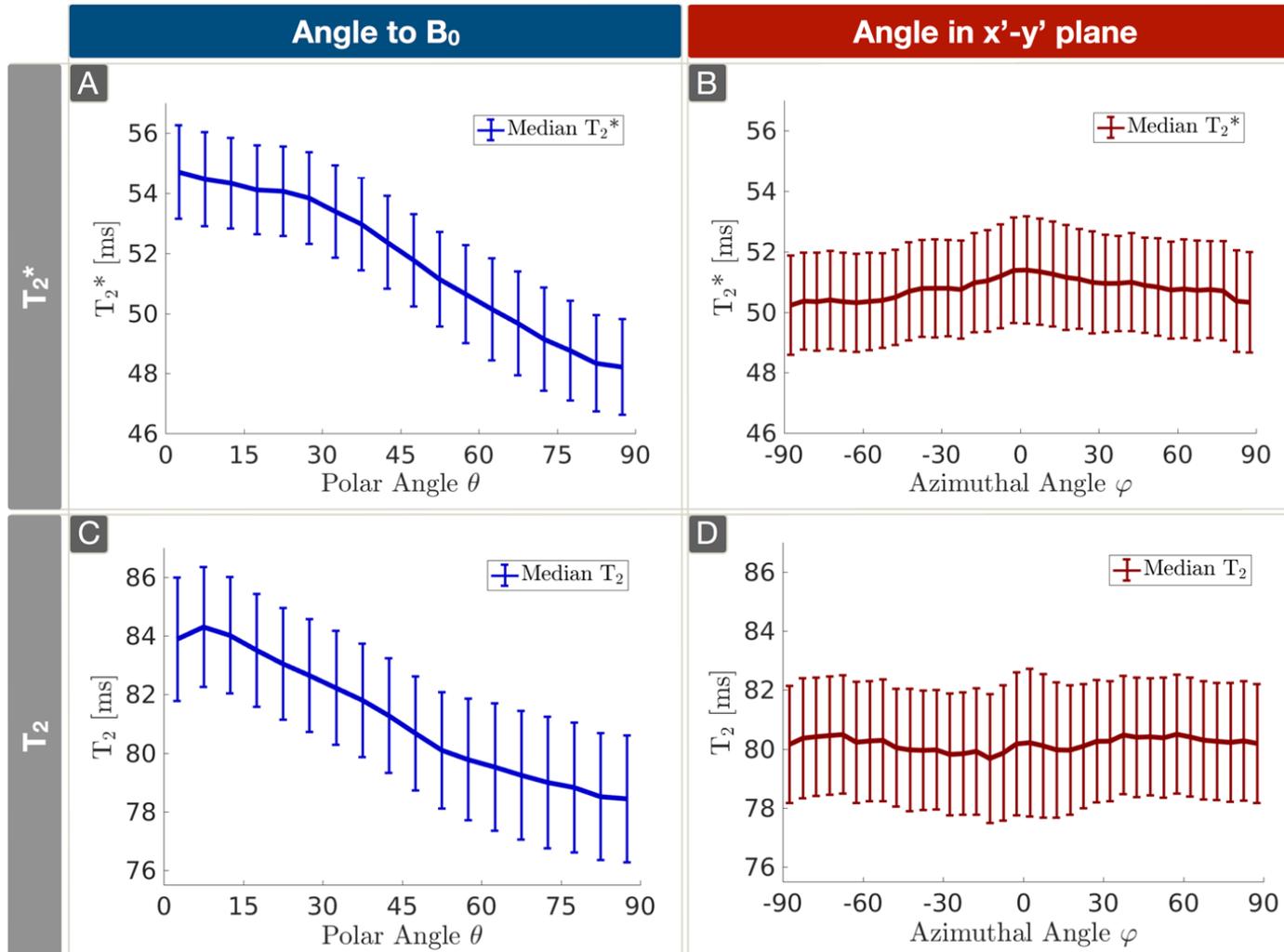
Results

Exemplary data



Results

T₂^{*} & T₂ orientation effects



- $\Delta T_2^*(\theta) = 6.5 \text{ ms} \hat{=} 13.5 \%$
- $\Delta R_2^*(\theta) = 2.5 \text{ Hz}$
- $\Delta T_2(\theta) = 5.9 \text{ ms} \hat{=} 7.5 \%$
- $\Delta R_2(\theta) = 0.9 \text{ Hz}$



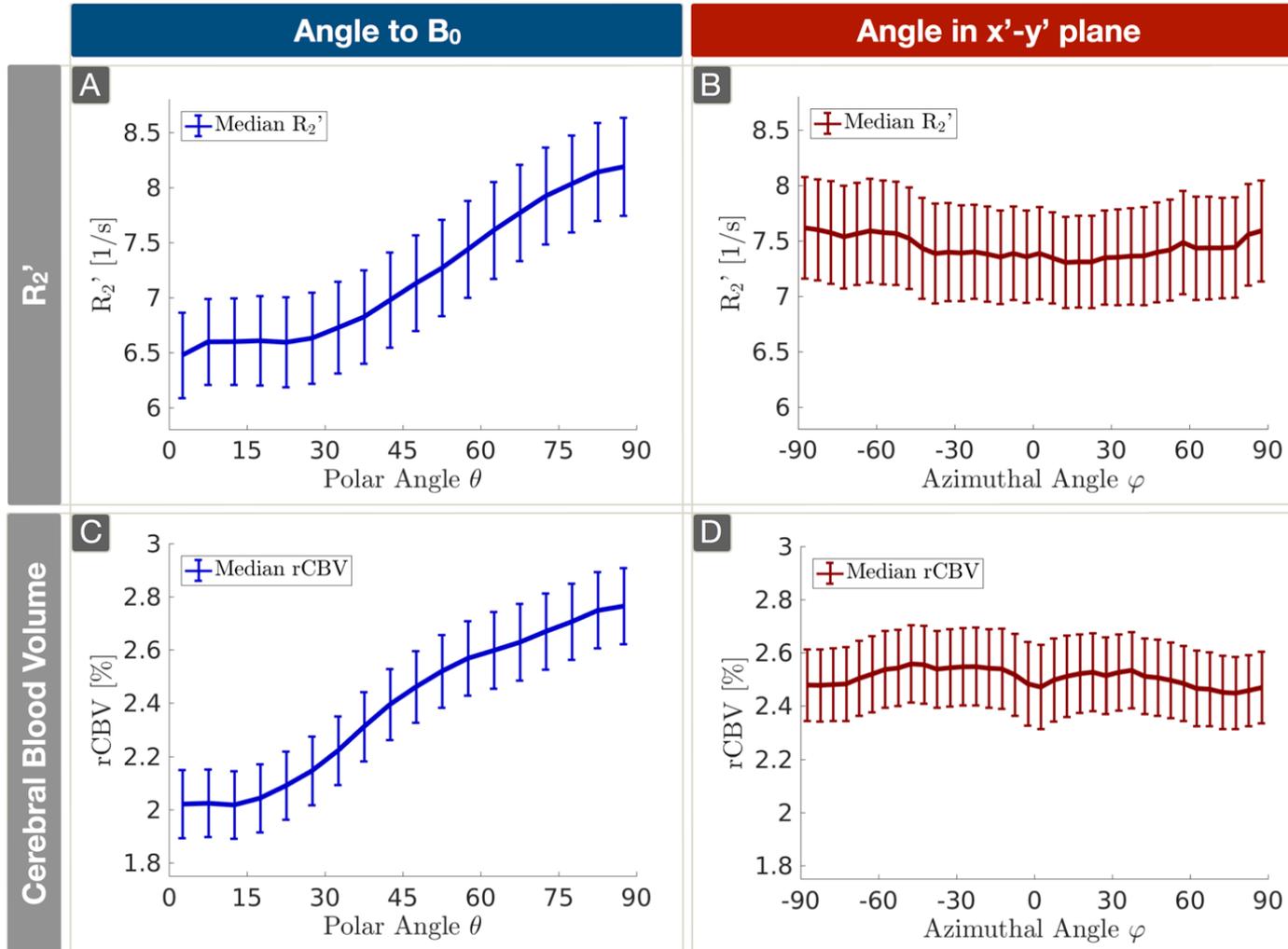
Strong T₂^{*} and T₂ orientation effects relative to B₀



No orientation effects in the plane ⊥ B₀

Results

R_2' & rCBV orientation effects



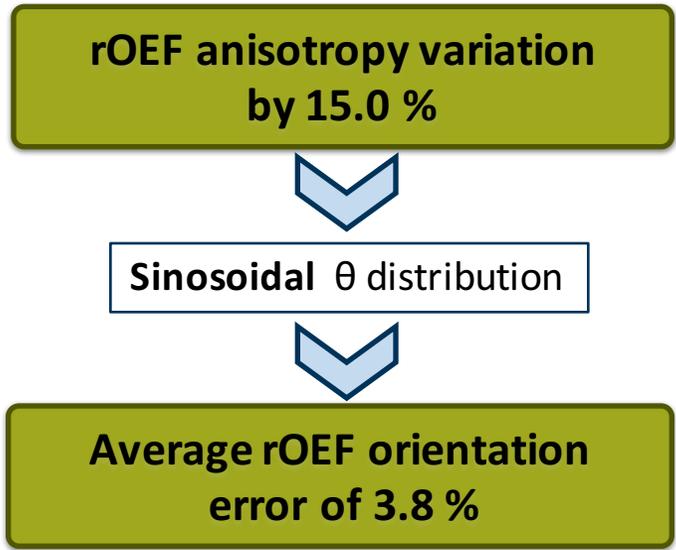
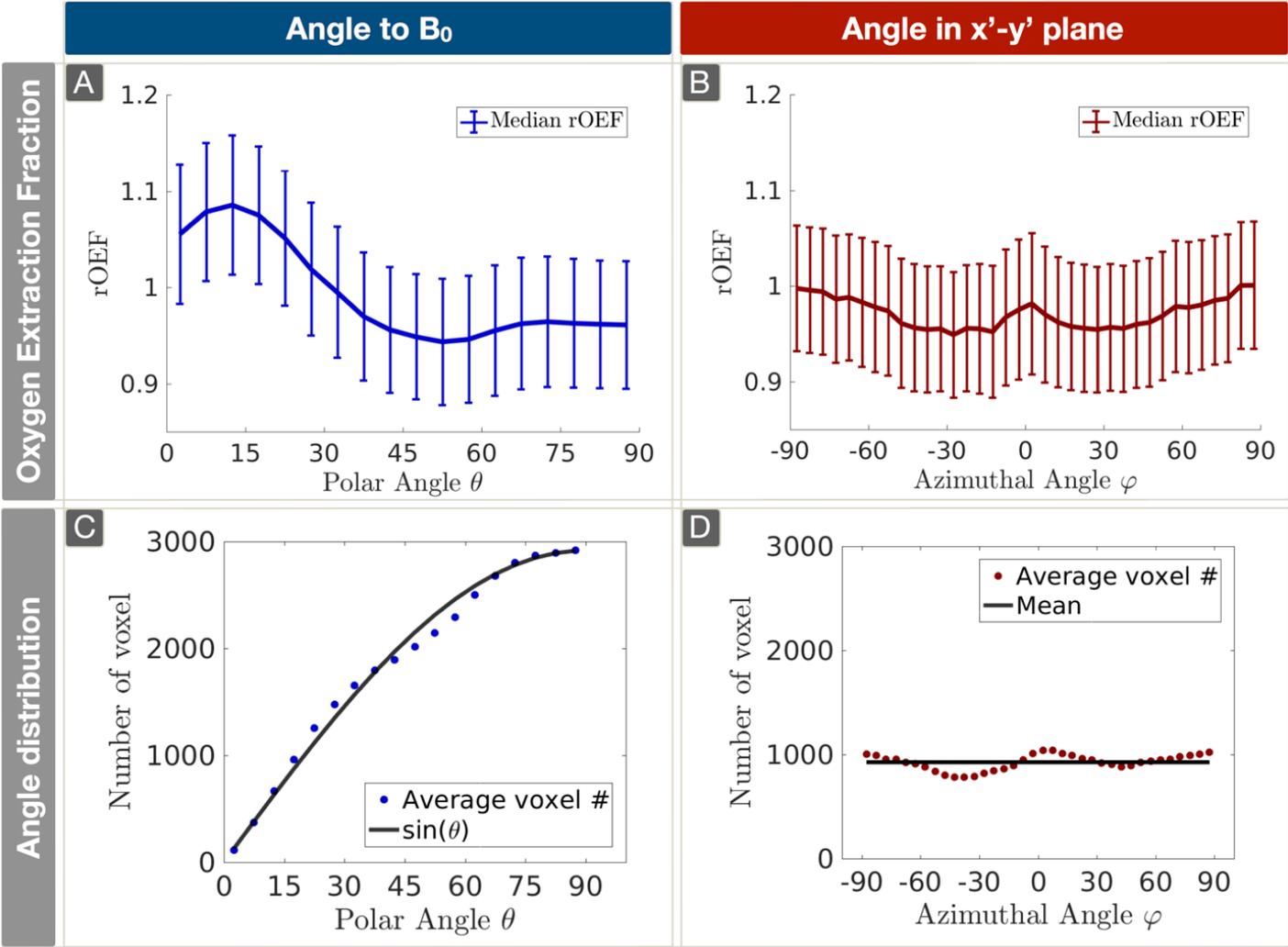
- $\Delta R_2'(\theta) = 1.7 \text{ Hz} \hat{=} 26.5 \%$
- $\Delta rCBV(\theta) = 0.8 \%$ $\hat{=} 37.1 \%$



Very strong R_2' and rCBV orientation effects relative to B_0

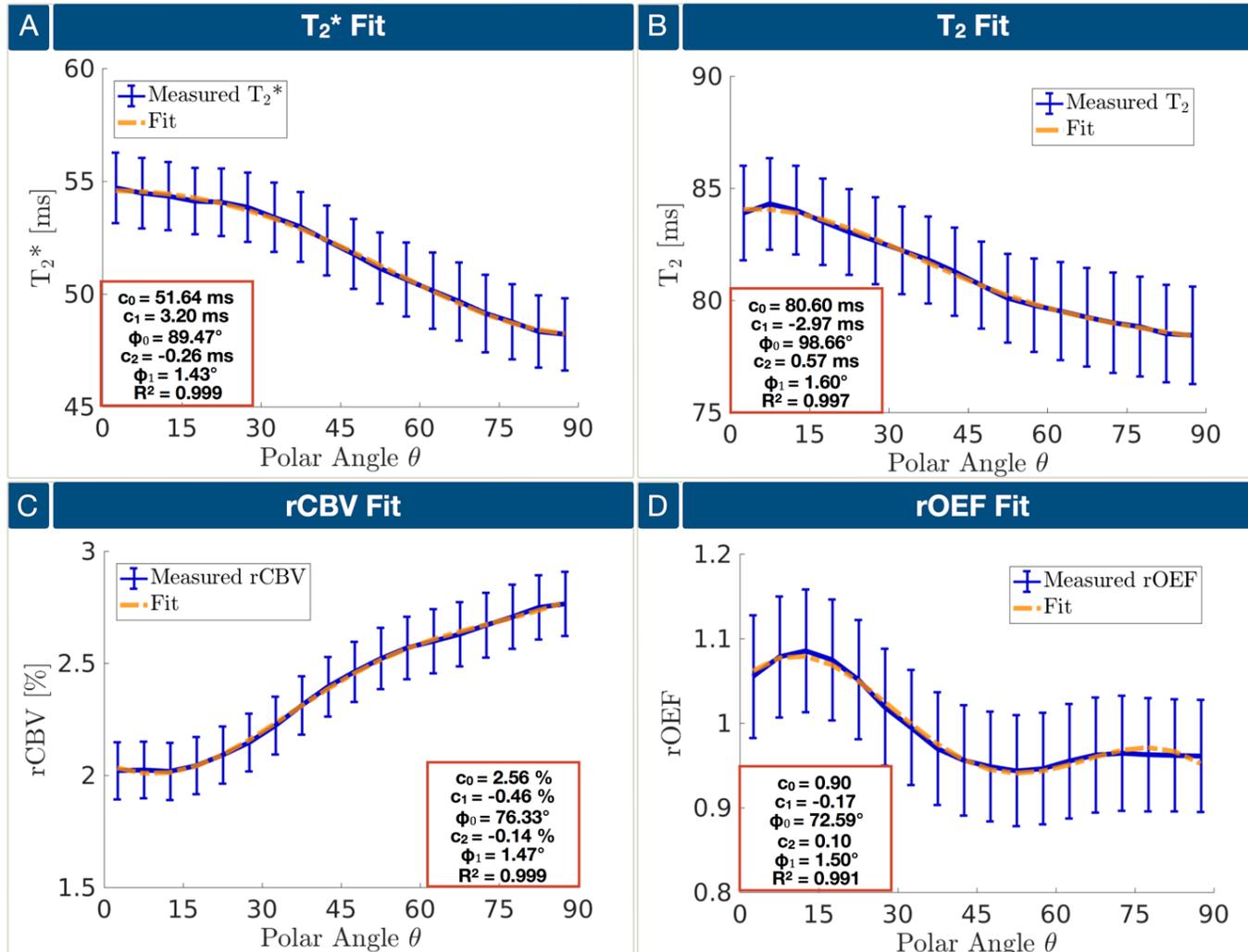
Results

rOEF orientation artefacts



Discussion

Fits & orientation effect origins



Lee's Model

- Highly non-random, non-isotropic perturber distributions
- Magnetic susceptibility anisotropy

$$S(\theta) = c_0 + c_1 \sin(2\theta + \phi_0) + c_2 \sin(4\theta + \phi_1)$$

T₂* & rCBV orientation effects:

Highly ordered myelin-fiber structures

Preferentially oriented vasculature

T₂ orientation effects:

Diffusion preferred along myelin sheaths

Summary

Successful quantitative analysis of mq-BOLD orientation effects

Confirmed strong orientation effects of T_2^* , T_2 and rCBV

rOEF with average orientation effect error of 3.8 %



Reliable rOEF mapping by mq-BOLD in WM
with respect to anisotropy effects

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Andreas Hock

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**Thank you very much
for your attention!**