



JPND Symposium  
November 27th – 28th , 2024  
Royal Museums of Fine Arts of Belgium, Brussels

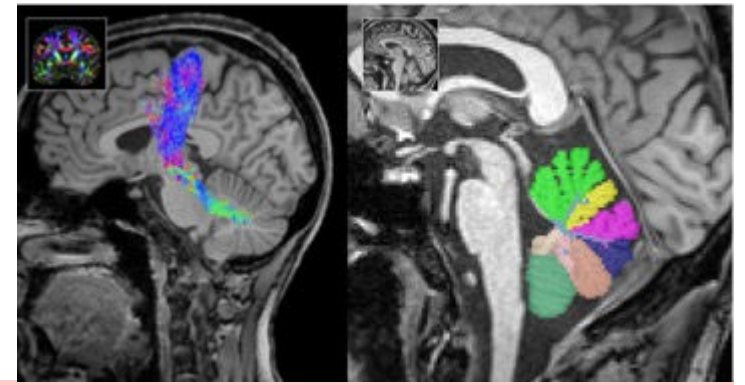
***SCAIFIELD***  
***a multi-center 7T study on Ataxia***

Tony Stöcker  
DZNE Bonn

# Outline

- The SCAIFIELD project
- Whole-brain qMRI at 7T
- Initial Results
- Summary and outlook

## Spinocerebellar ataxias (SCA)



Carrier stage

Biomarker stage

Ataxia stage

Ataxic

Walking aid

Wheelchair

Birth

Ataxia onset

- SCA: most common autosomal dominantly inherited progressive ataxia disorders worldwide
- First gene-therapies with a gene silencing approach have started. They might be preventive.
- Early (imaging) biomarkers would enable trials in the pre-ataxic stage!



# The SCAIFIELD project



**Goal:** Develop quantitative MRI methods for whole-brain imaging at ultra-high field (7T) and apply the novel technology in a multi-center study on spinocerebellar ataxia (SCA) patients

**Challenge:** Cerebellum imaging at 7T

## PIs

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Ergin Atalar, Bilkent University, Ankara, Turkey

## Advisory Board

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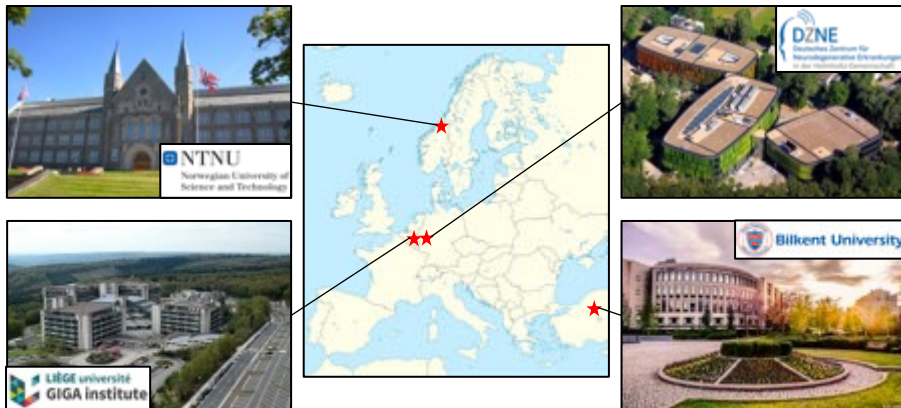
Robin Heidemann, UHF Group, Siemens Healthineers

Cathalijne van Doorne and Julie Greenfield, Euro-Ataxia



## PPI activities

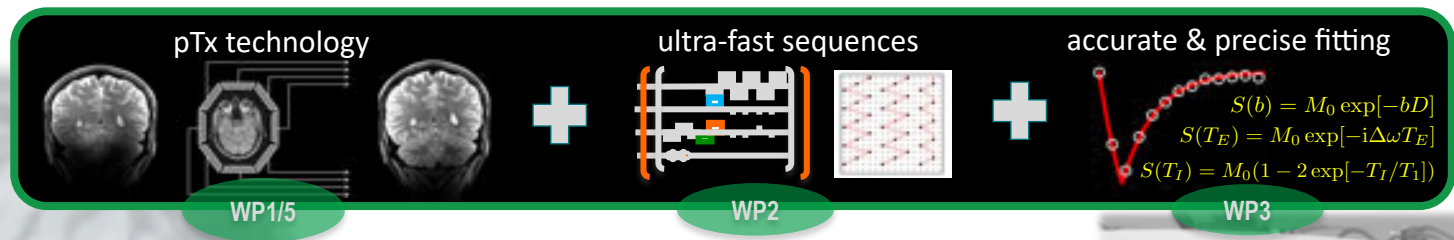
- (i) Incorporate patient perspective in study design
- (ii) Providing easy-to-read information about research outcomes
- (iii) Explain possibilities to participate in clinical enrolment



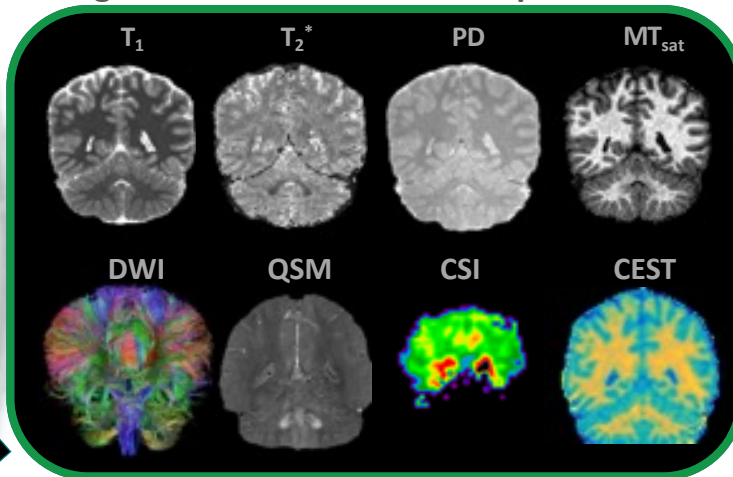
# The SCAIFIELD project



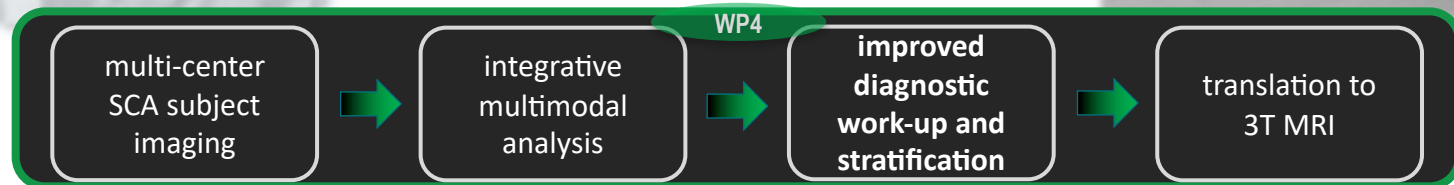
## I. Method development: UHF-Neuroimaging including cerebellum and brainstem



## II. High-resolution whole-brain qMRI @ 7T

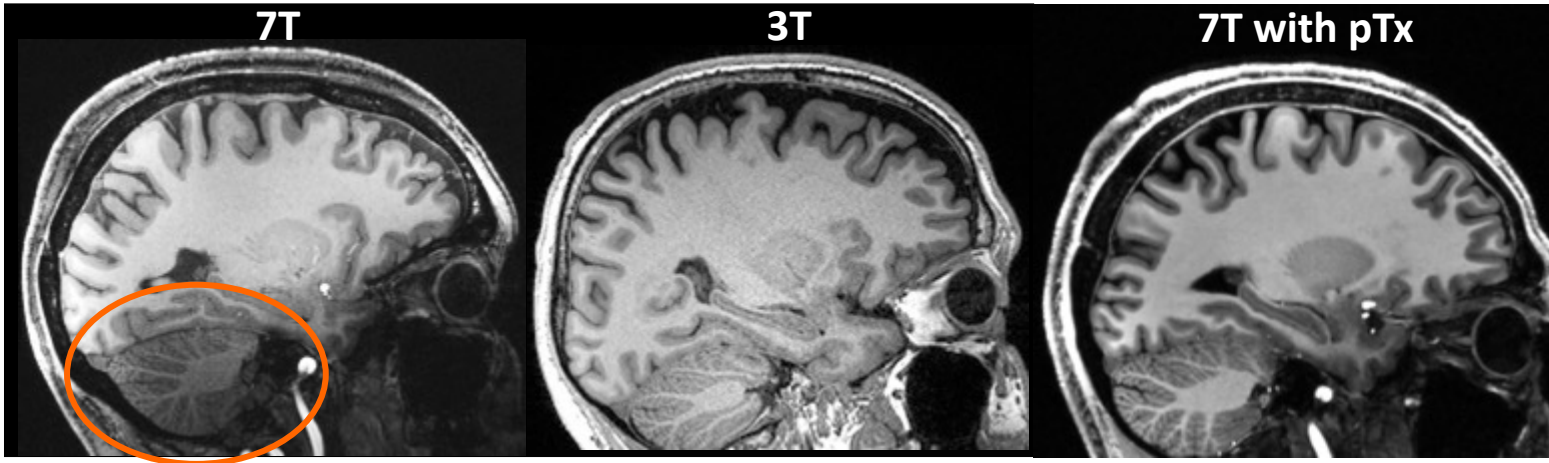


## III. Advanced Imaging of Spinocerebellar Ataxia





# Ataxia Imaging @ 7T $\Rightarrow$ mitigating B1 inhomogeneity (transmit field)

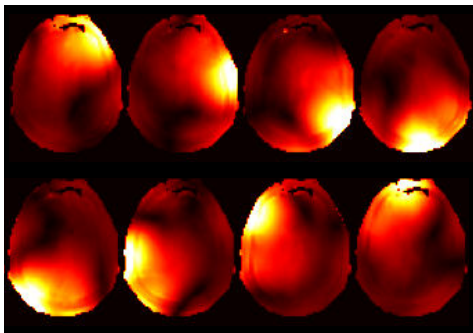


... without lengthy subject-specific calibration !

## Universal Pulses<sup>1</sup>

- pTx pulses, which homogenize B1 for data base of subjects
- UPs generalize, i.e. they also perform on new subjects

parallel transmission (pTx)

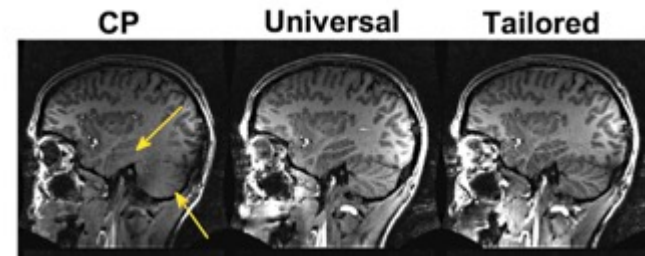


SCAIFIELD



multi-channel

- ~~• Acquire B1 maps per channel~~
- ~~• Acquire B0 map~~
- ~~• Calculate pTx RF pulses ( $\Sigma \approx 5-10$  min)~~
- ~~• Apply pulses in sequence~~

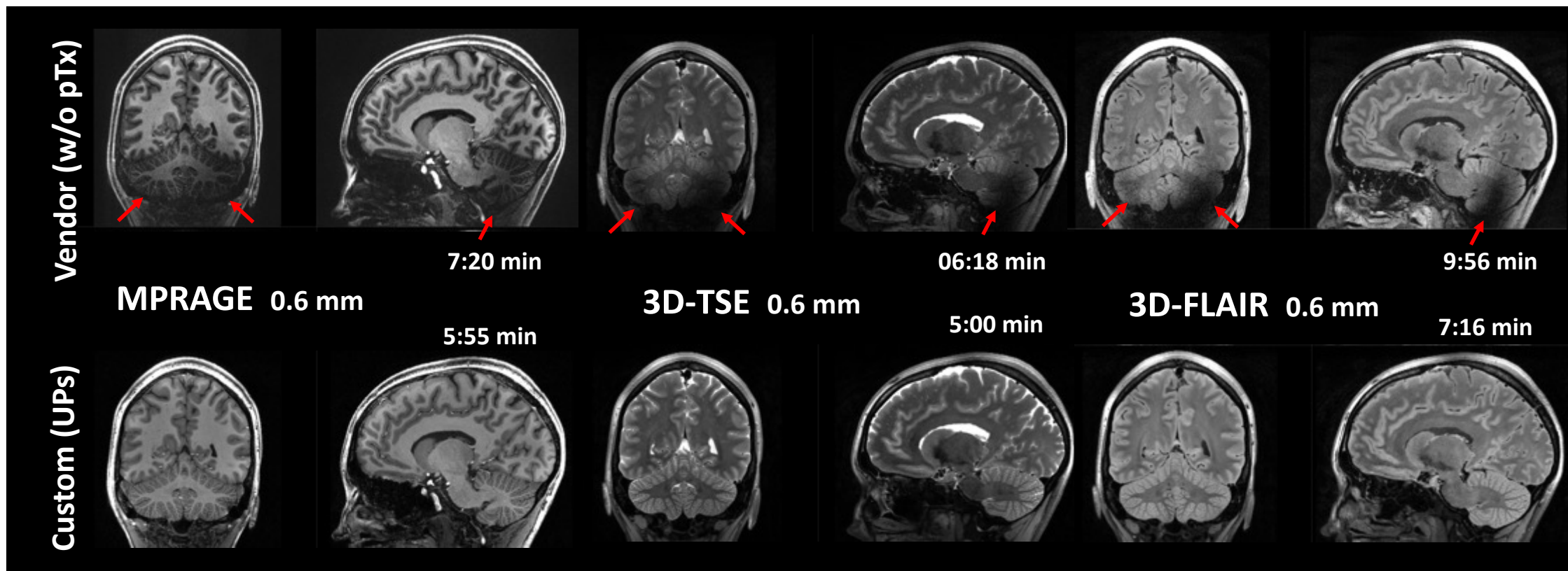


<sup>1</sup> Gras et al, MRM 2017

# SCAIFIELD method development: rapid whole-brain 7 Tesla MRI

Custom sequences with tailored Universal Pulses (UPs) and ultra-fast imaging readouts

- UP calculation <sup>1,2,3,4</sup> with BLT database (Bonn-Liège-Trondheim field-map database collection > 70 subjects)
- Fast readouts <sup>5,6,7,8</sup> combining 2D parallel imaging, partial Fourier, elliptical sampling, EPI factor, and compressed sensing



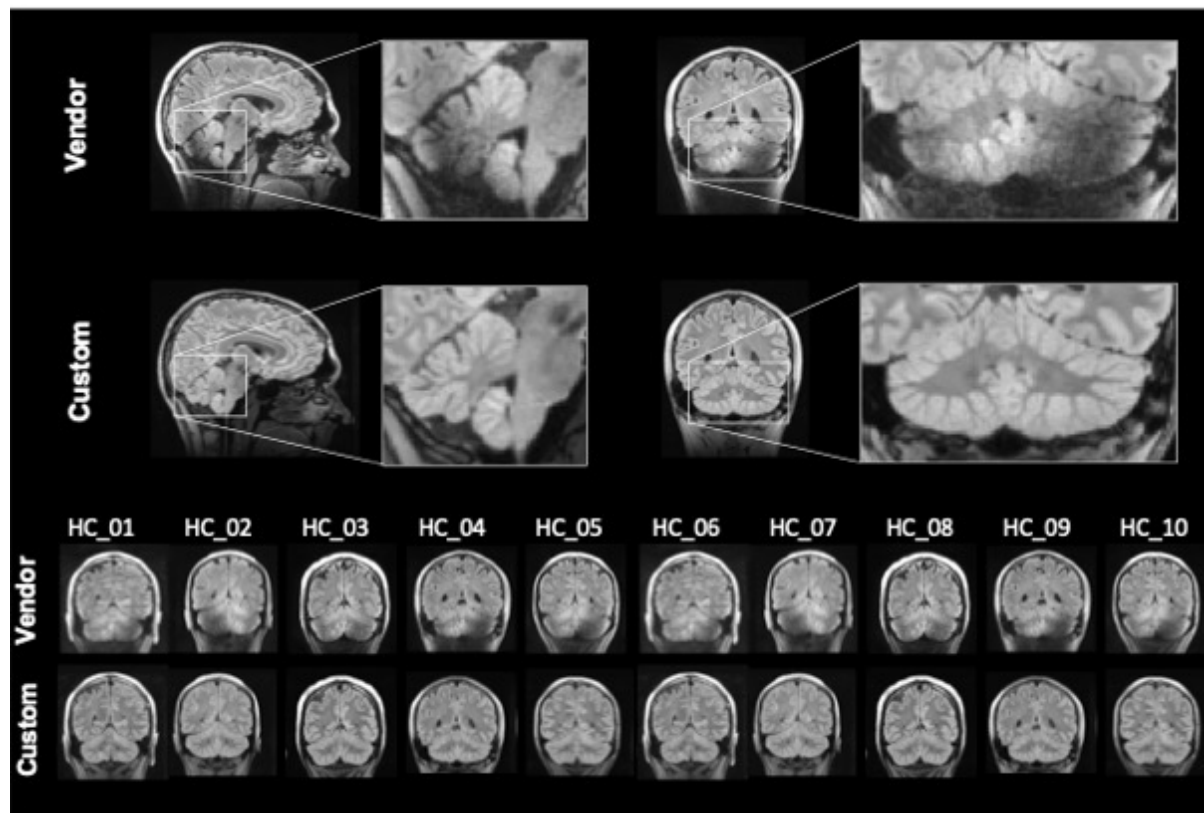
<sup>1</sup> Löwen et al, *MRM* 2022, 8(86): 2564–72; <sup>2</sup> Gras et al., *MRM* 2018, 80:53–65; <sup>3</sup> Gras, et al, *MRM* 2019, 81(5): 3202–8; <sup>4</sup> Löwen et al, *MRM*, 2024.

<sup>5</sup> Brenner et al, *Magma* 2014, 27(5):455–62. <sup>6</sup> Pracht et al, *MRM* 2018, 79(5): 2620–28; <sup>7</sup> Stirnberg and Stöcker, *MRM* 2022, 85:1540-1551; <sup>8</sup> Stirnberg et al, *MRM* 2024

# SCAIFIELD method development: rapid whole-brain 7 Tesla MRI

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### Custom sequences:

- pTx  $\Rightarrow$  homogenous whole-brain MRI
- UPs  $\Rightarrow$  calibration-free and robust
- Advanced readouts  $\Rightarrow$  high SNR/CNR
- MP-RAGE, 3D TSE, 3D FLAIR

<sup>1</sup> Löwen et al, *MRM* 2022, 8(86): 2564–72; <sup>2</sup> Gras et al., *MRM* 2018, 80:53–65; <sup>3</sup> Gras, et al, *MRM* 2019, 81(5): 3202–8; <sup>4</sup> Löwen et al, *MRM*, 2024.

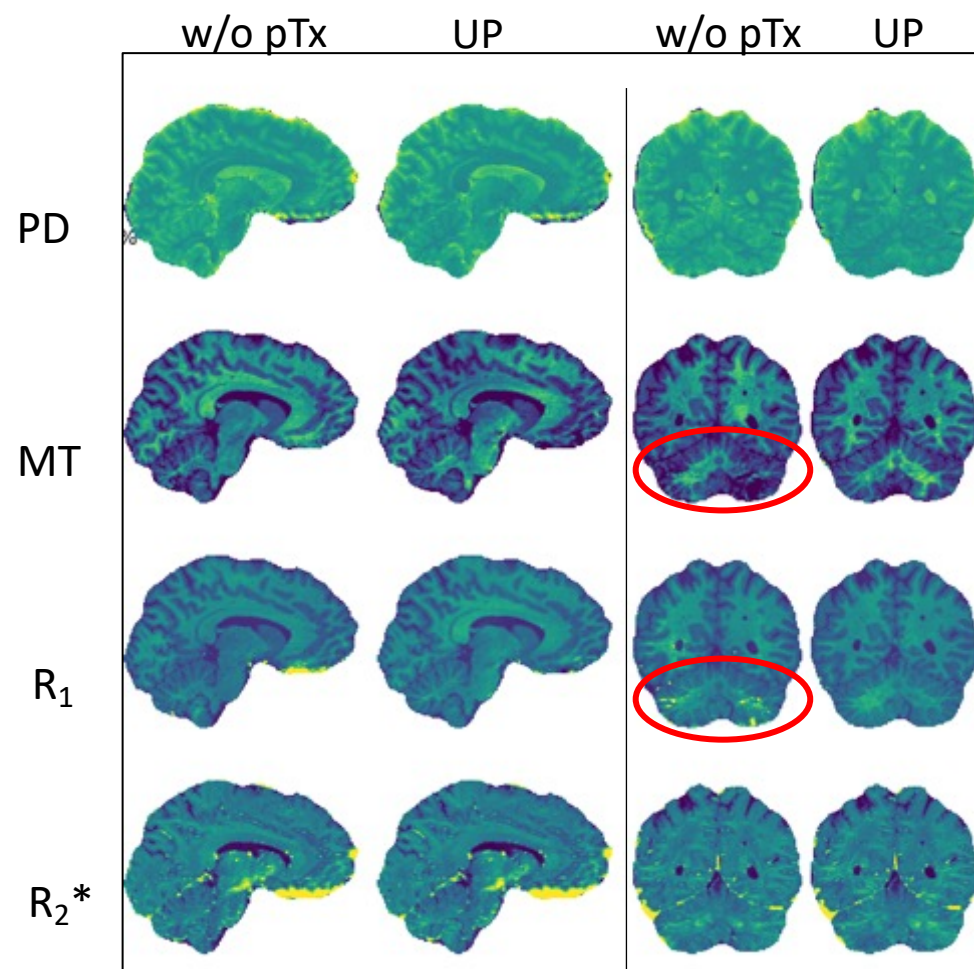
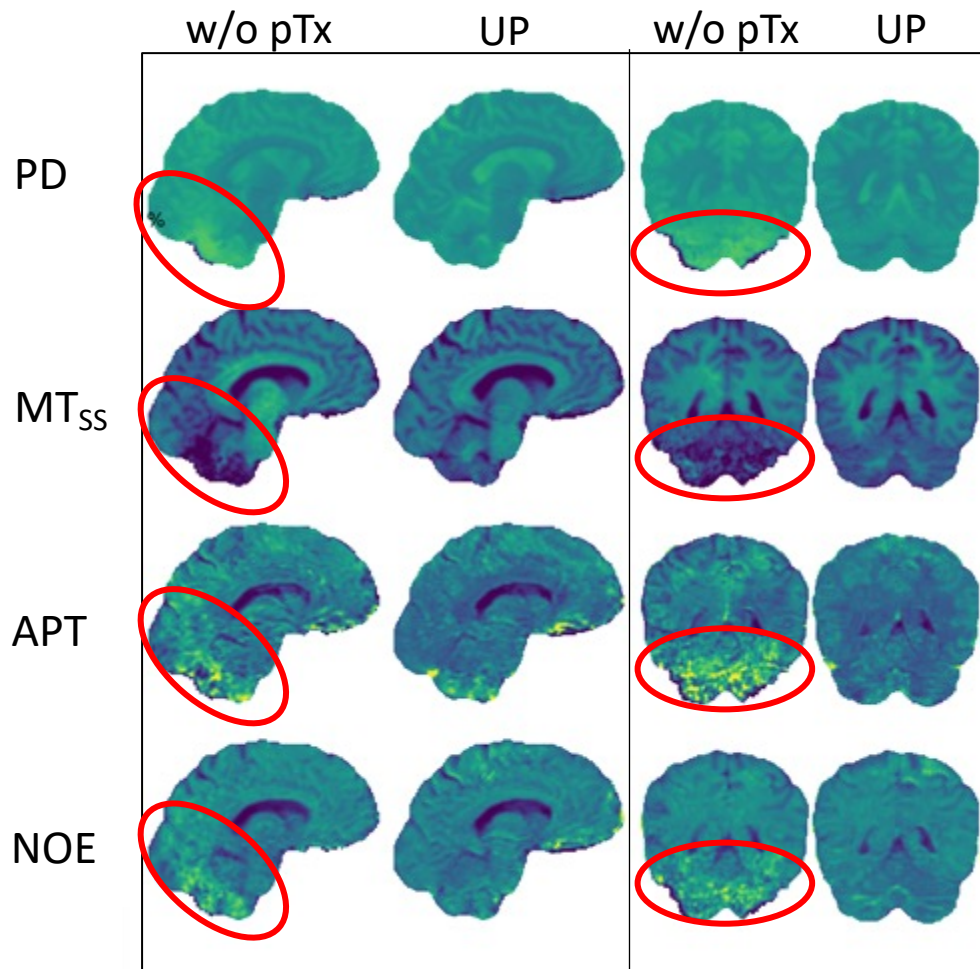
<sup>5</sup> Brenner et al, *Magma* 2014, 27(5):455–62. <sup>6</sup> Pracht et al, *MRM* 2018, 79(5): 2620–28; <sup>7</sup> Stirnberg and Stöcker, *MRM* 2022, 85:1540-1551; <sup>8</sup> Stirnberg et al, *MRM* 2024



# rapid quantitative and molecular whole-brain MRI @ 7T

Chemical Exchange Saturation Transfer<sup>1</sup> (CEST) - 1.6 mm iso

Multi-Parametric Mapping<sup>2</sup> (MPM) - 0.6 mm iso



<sup>1</sup>Völzke et al. "PUSHUP-CEST: Calibration-free whole-brain ultra-high field CEST imaging using universal parallel transmission", MRM 2024

<sup>2</sup>Wang, Ehses, Stöcker, Stirnberg. "Reproducibility of Rapid MPM at 3T and 7T with Highly Segmented and Accelerated 3D-EPI." MRM 2022 88(5): 2217–32.



## SCAIFIELD: 7T-qMRI Acquisition Protocol

#	Contrast (Method)	Resolution / mm <sup>3</sup>	Coverage	Duration / min	Quantitative Analysis	Hypothesis
1	B0 & B1 map (3DREAM)	5.0 x 5.0 x 5.0	whole brain	02:38	Calibration: flip angle maps and field maps	(→ qMRI analysis)
2	MPRAGE	<b>0.6 x 0.6 x 0.6</b>	whole brain	07:24	segmentation / volumetry	volume loss <sup>1</sup>
3	MPM + QSM (segm. 3D-EPI)	<b>0.6 x 0.6 x 0.6</b>	whole brain	13:41	T1, T2*, PD, MT, QSM / volumetry	T1, T2* reduction <sup>2</sup> (PD, MT?) / volume loss / iron load <sup>2</sup>
4	CEST (segm. 3D-EPI)	<b>1.6 x 1.6 x 1.6</b>	whole brain	07:37	Amides, NOE (?)	decreased?
5	DWI (SMS-SE-EPI, 2-shell HARDI)	<b>1.5 x 1.5 x 1.5</b>	whole brain	10:44	Microstructure & connectivity: e.g. DTI, NODDI, tractography	reduced connectivity / cerebellar demyelination <sup>3,4</sup>
6	MRSI (3D-CRT)	<b>5.0 x 5.0 x 5.0</b>	cerebellum	08:56	Neurochemical profile: Cr, Glu, Gln, NAA, ...	MRS Score: SCA classification <sup>5</sup>

≈ 52 min



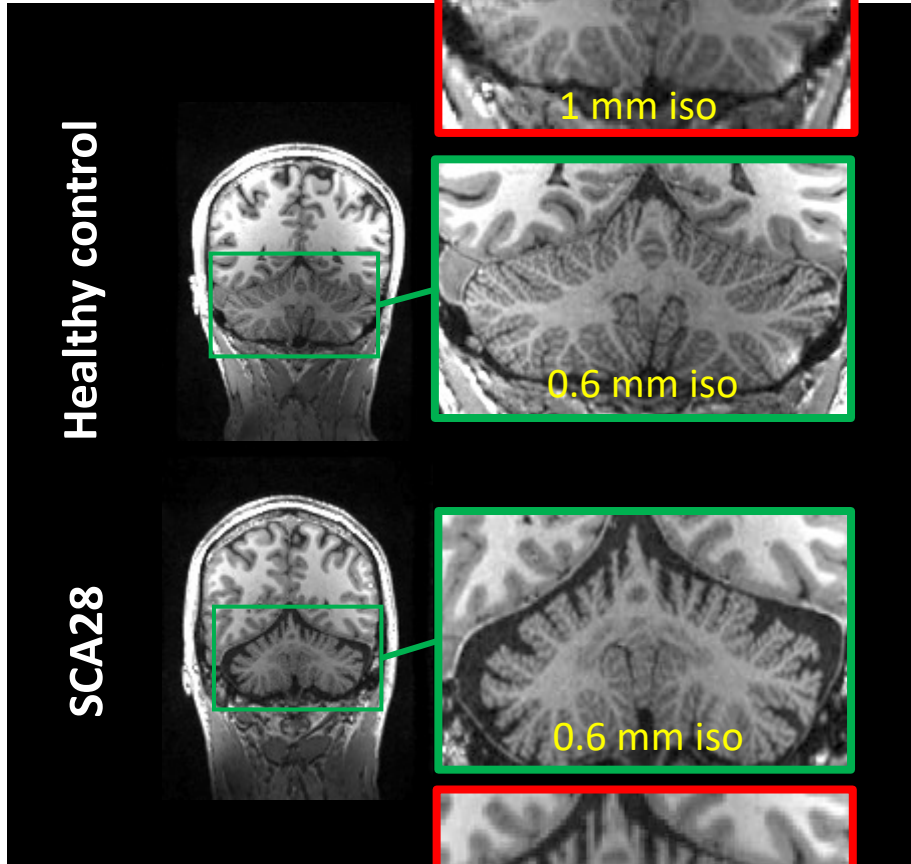
1. Reetz K et al., *Brain* 136, no. 3 (2013)
2. Deistung A et al., *Brain Comm.* 4, 2022
3. Mascalchi M, et al. *PLoS One* (2018)

4. Piccinin CC, et al. *Mov Disord.* (2020)
5. Joers JM et al., *Annals Neurology* 83, (2018)

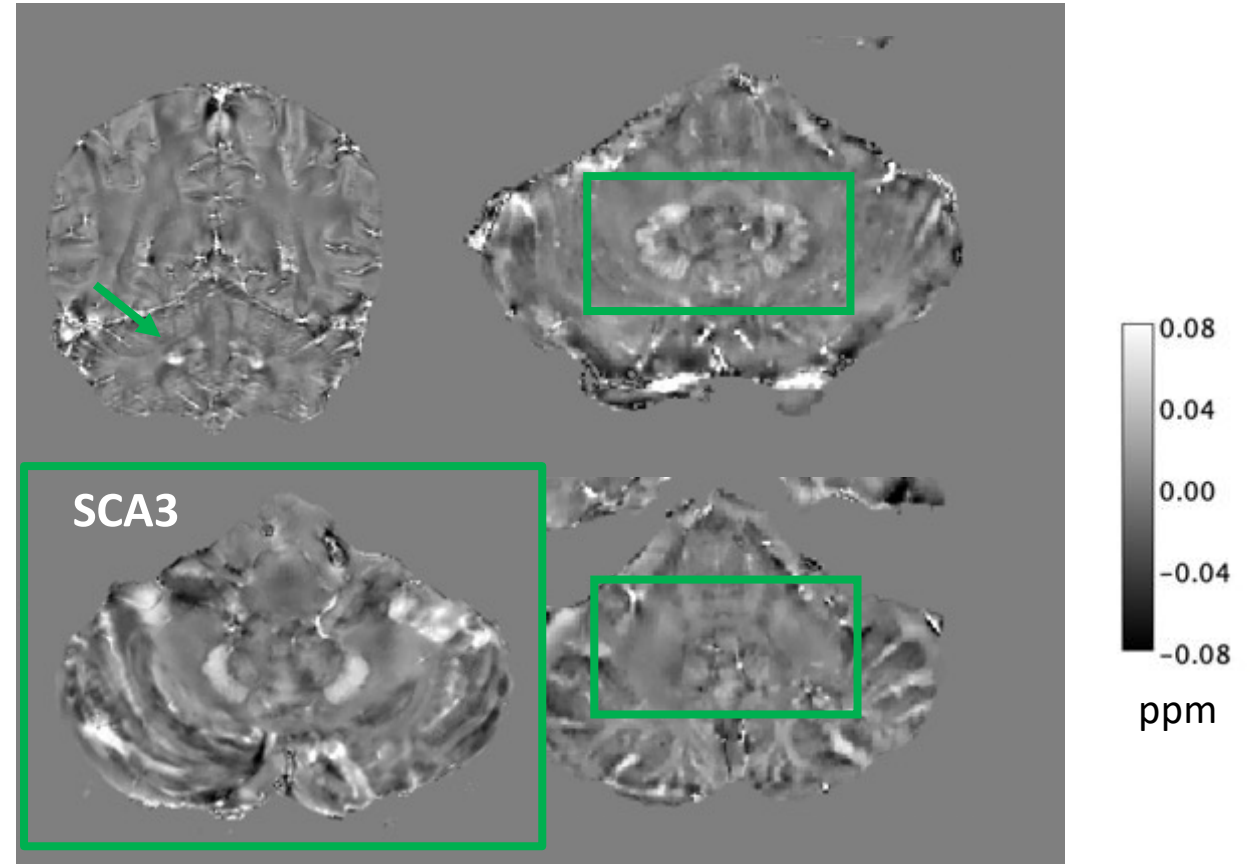


# Example Patient Data

MPRAGE

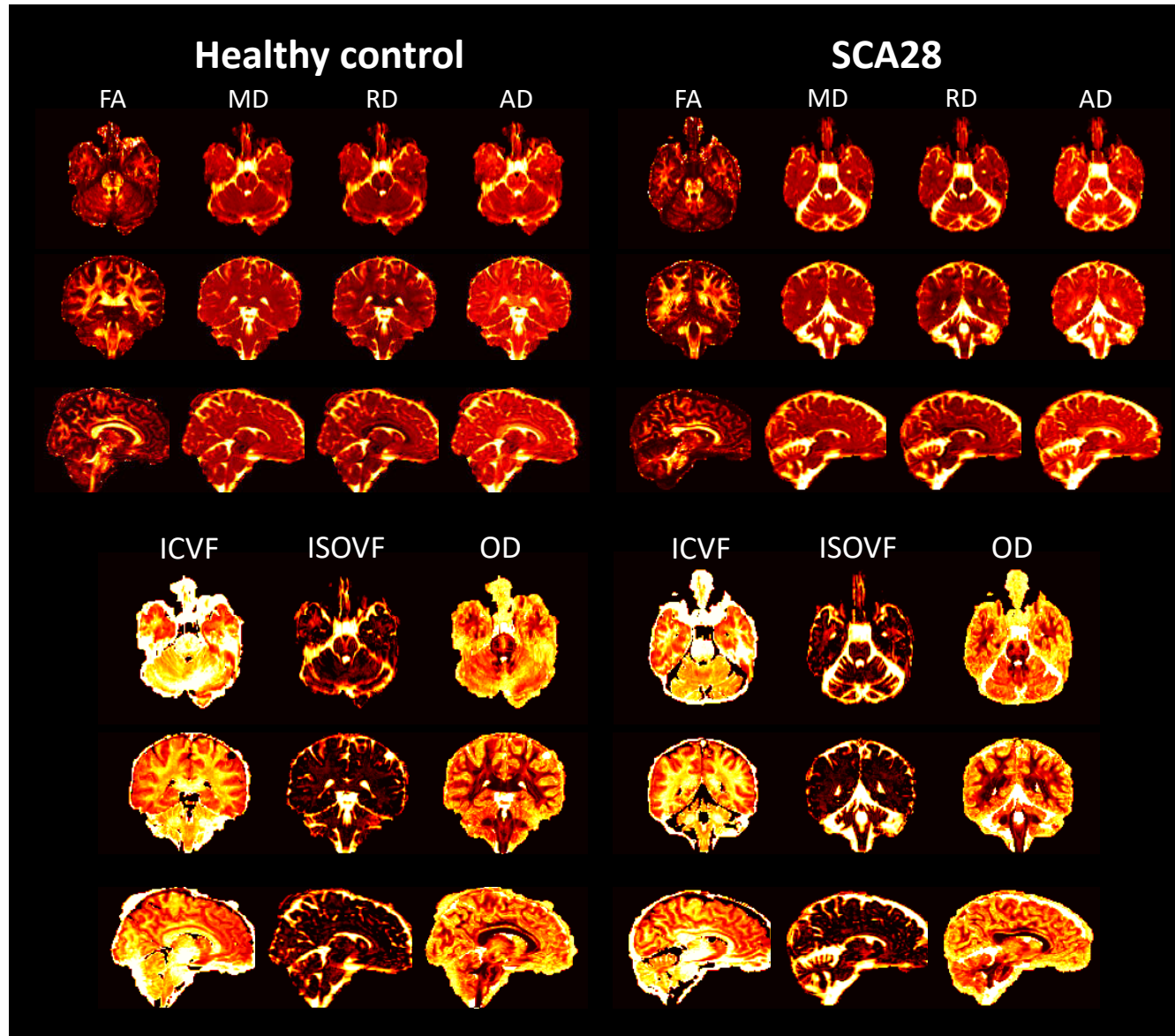
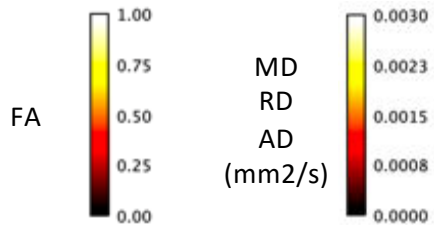


Quantitative Susceptibility Mapping (QSM)



# Example Patient Data

**Diffusion:**  
brain microstructure  
(1.5 mm iso)



## DTI

FA: Fractional anisotropy

MD: Mean diffusivity

RD: Radial diffusivity

AD: Axial diffusivity

## NODDI

ICVF: Intracellular Volume Fraction

ISOVF: Isotropic Volume Fraction

OD: Orientation Dispersion



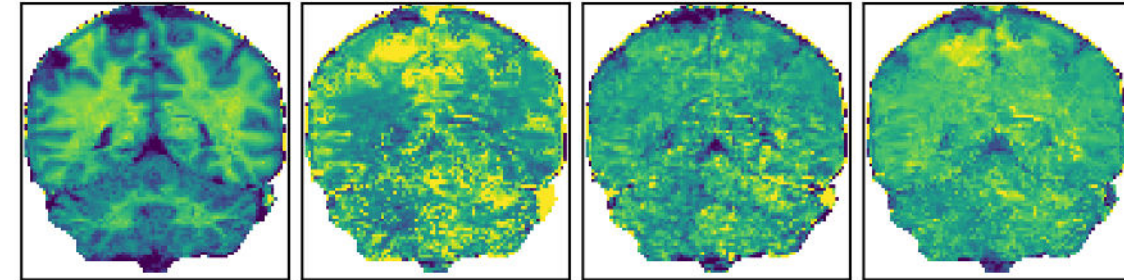
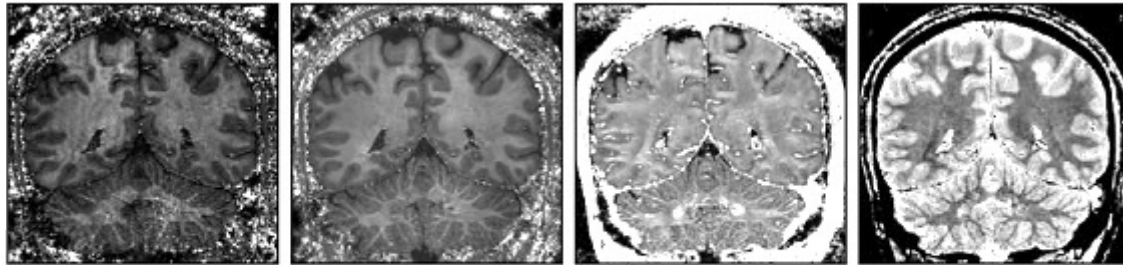
# Example Patient Data

## Tissue parameter mapping: molecular information

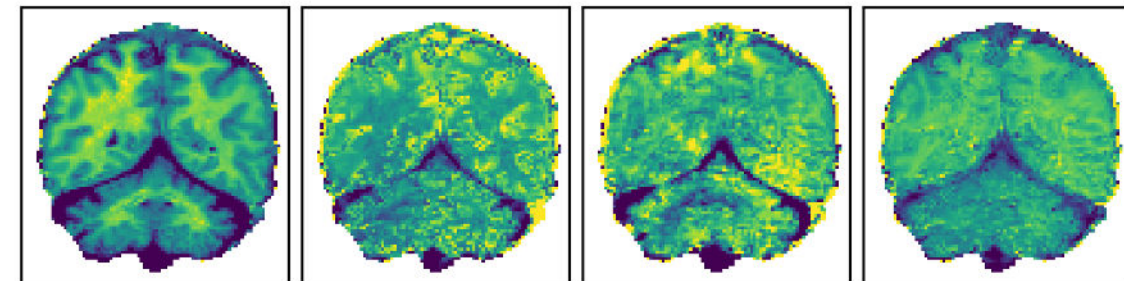
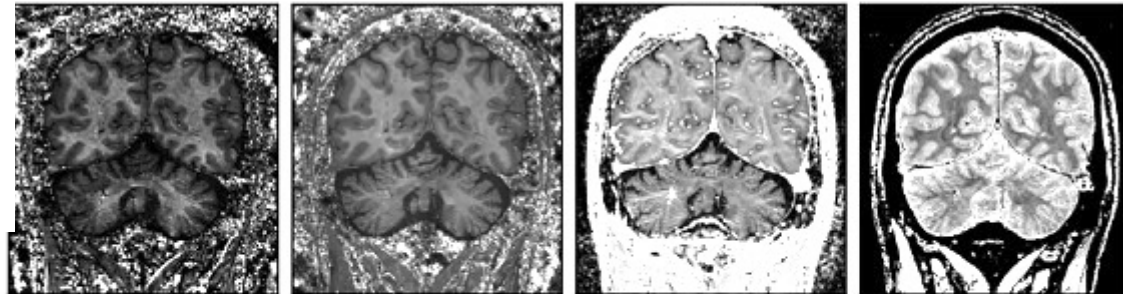
Multi-Parametric Mapping (MPM) - 0.6 mm iso

Chemical Exchange Saturation Transfer (CEST) - 1.6 mm iso

HC



SCA28



0 1 2 3  
MTsat / %

0 0.5 1 1.5  
R1 / 1/s

0 25 50 75  
R2s / 1/s

50 75 100  
PD / %

0 10 20 30  
MT PA / %

0 4 8  
amide PA / %

0 3 6  
amine PA / %

0 10 20  
rNOE PA / %



# SCAIFIELD: summary and next steps

## SCAIFIELD Achievements

- Fast sequences for homogeneous whole-brain quantitative MRI at 7T with high resolution and image quality
- Tailored analysis pipelines with focus on cerebellum for brain segmentation, MPM, QSM, CEST, DWI, CSI
- Sequence role out at all SCAIFIELD sites (Bonn, Liège, Trondheim, Essen) / patient scanning started Q3 2024

## Next steps

- Ataxia patient study is ongoing and will finish in Q2 2025
- Automated global analysis pipeline and group analyses
- Backtranslation to 3T
- qMRI as early imaging biomarker for Ataxia (⇒ in future, therapy monitoring in pre-ataxic stage?)

## Impact beyond the project

- Imaging protocol ready for clinical research, paving the way for increased routine use of 7T MRI
- Sequences will be made freely available in Q1 2025 (for Siemens 7T Terra and 7T Plus, WIP: Terra.X)



# Acknowledgements



## SCAIFIELD Team

### Bonn

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# Thank You