

# Image quality transfer: history and progress

Daniel C. Alexander

Centre for Medical Image Computing (CMIC)

Dept. Computer Science

UCL

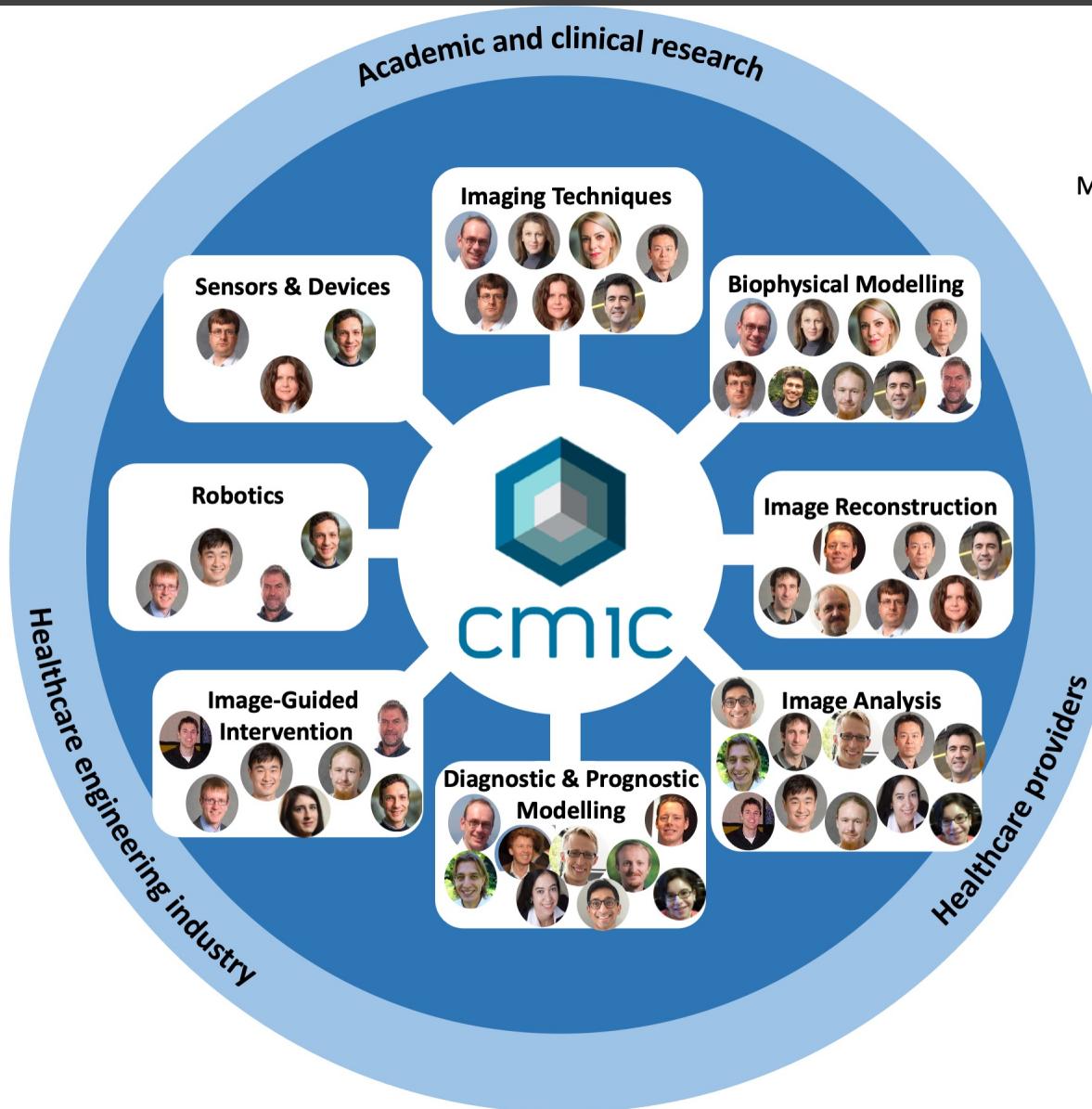


cmic

Centre for Medical Image Computing

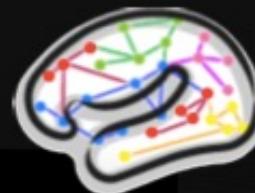
# CMIC Est. 2005 defines cutting edge medical image computing to drive 21<sup>st</sup> century diagnostic, prognostic, and interventional systems.

- Alexander
- Altmann
- Arridge
- Barkhof
- Barratt
- Betcke
- Clarkson
- Cole
- Drobnjak
- Hawkes
- Hu
- Iglesias



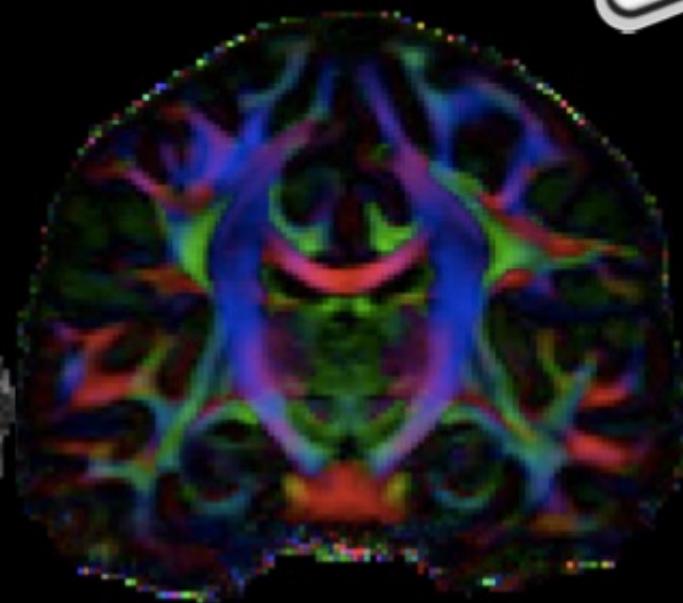
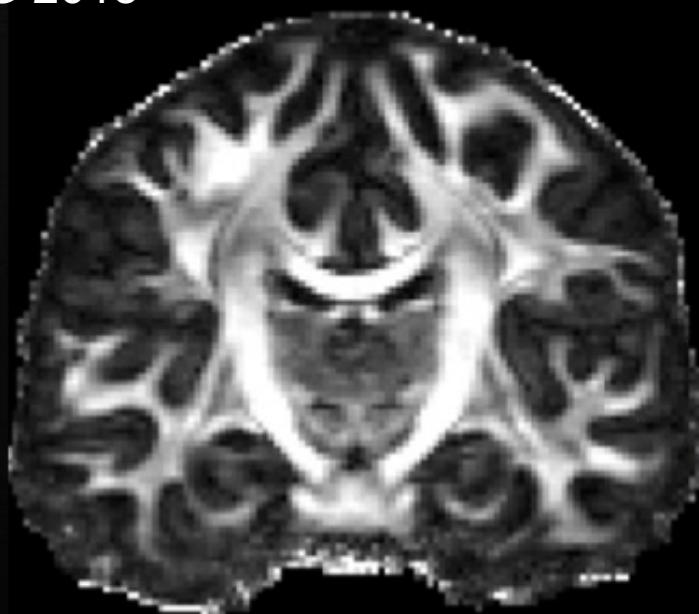
- Jacob
- McClelland
- Mourao-Miranda
- Oxtoby
- Palombo
- Panagiotaki
- Parker
- Stoyanov
- Sudre
- Thielemans
- Viega
- Vos
- Zhang

# DTI Anisotropy Maps

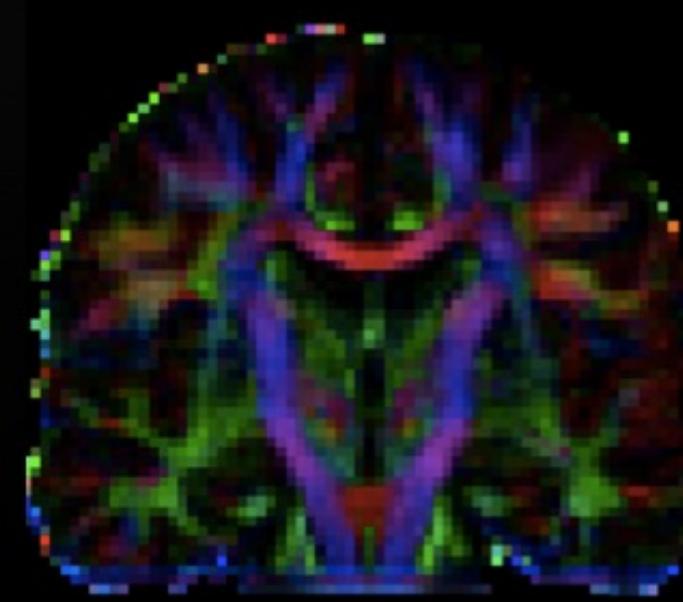
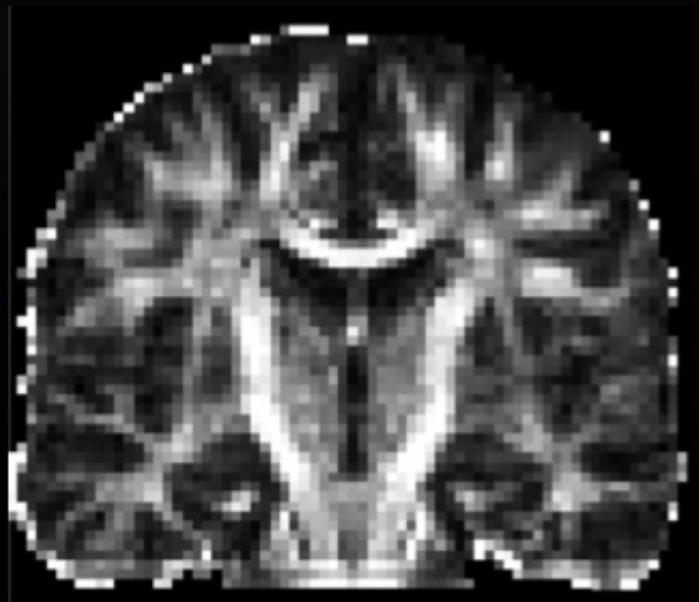


Sotiropoulos NIMG 2013

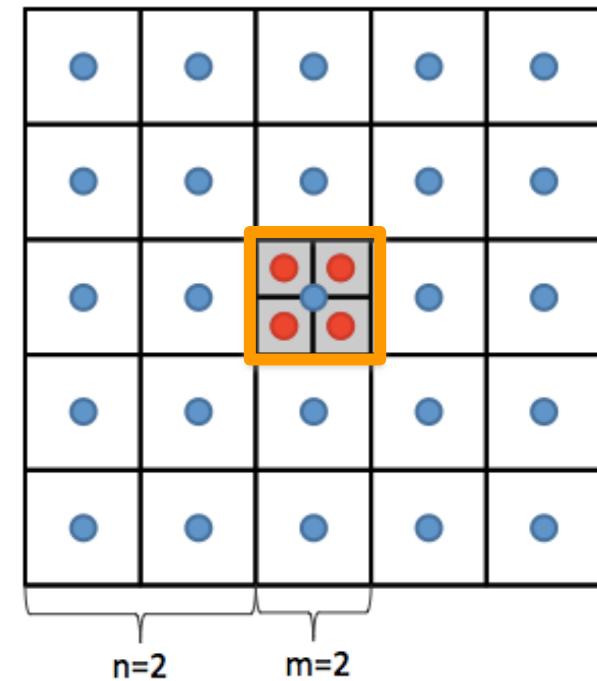
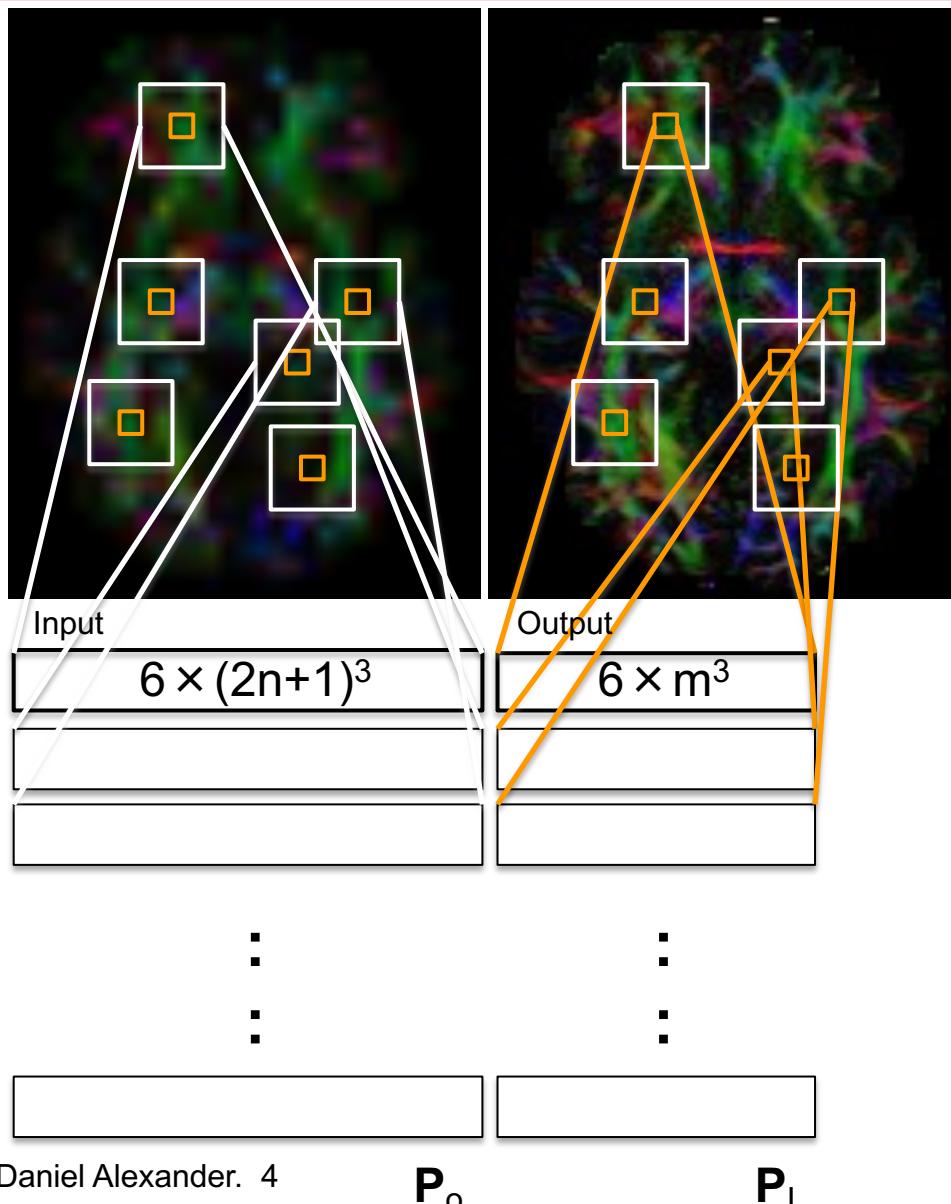
1.25mm  
isotropic,  
HCP 3T Skyra



2mm isotropic  
3T Verio



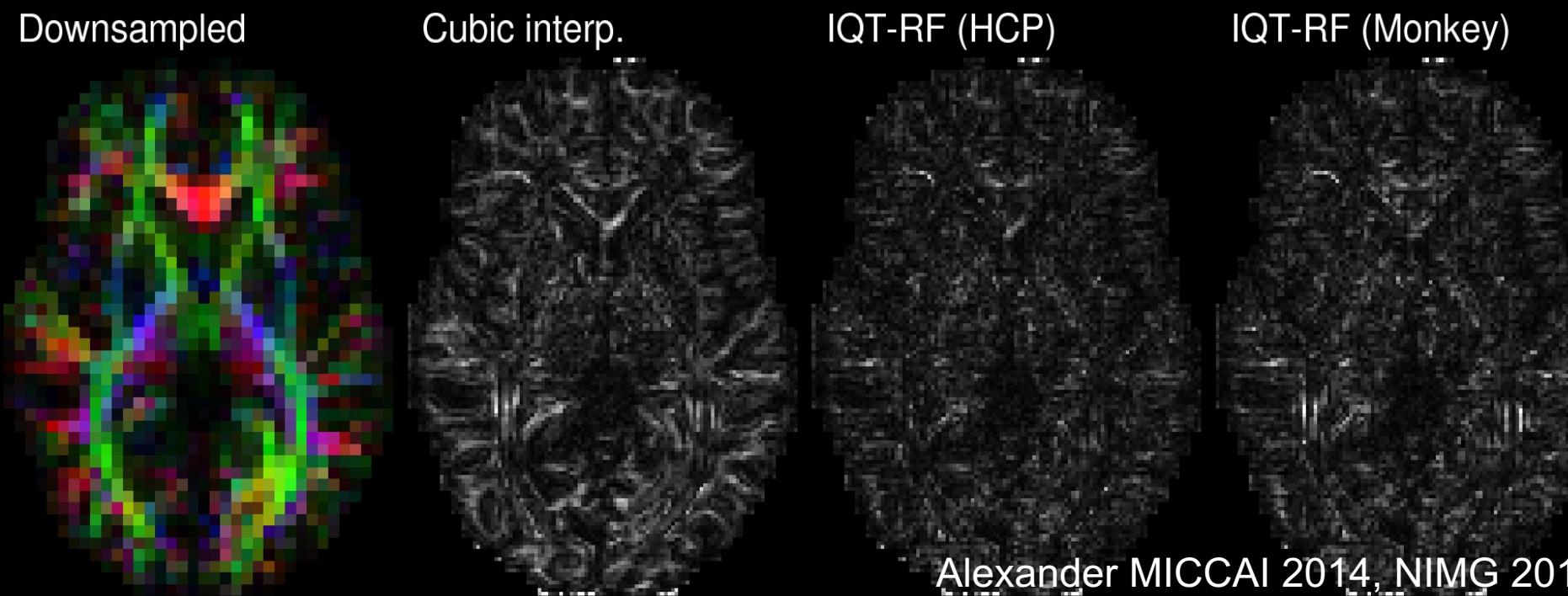
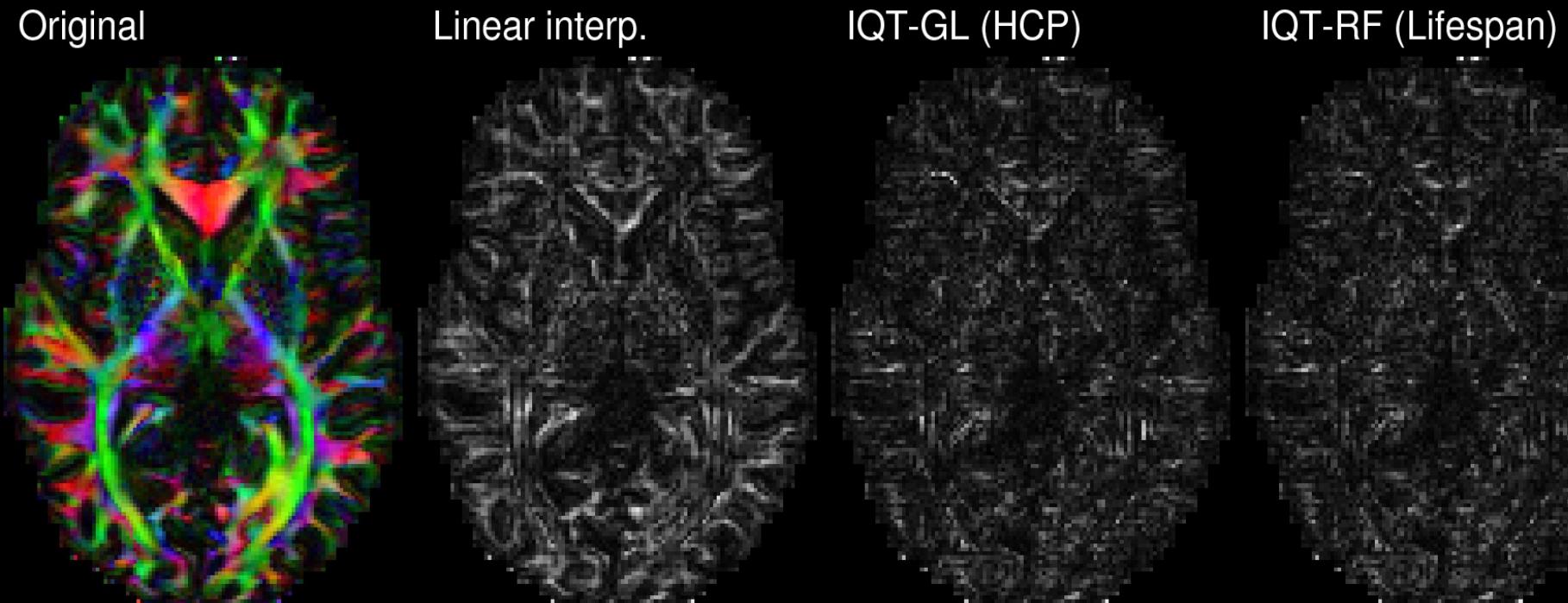
# Method: patch regression



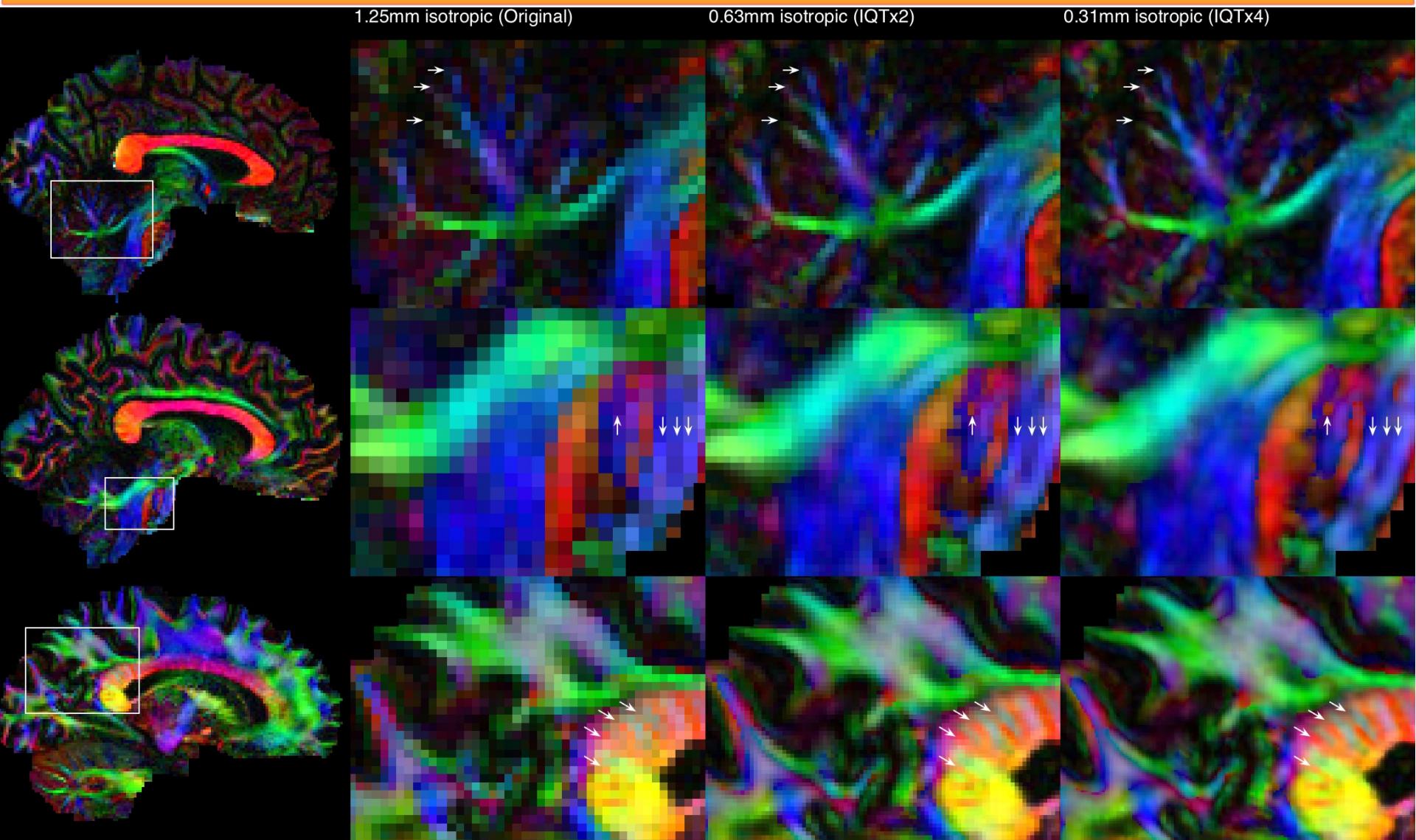
Global linear regression:

$$\mathbf{P}_o = \mathbf{X} \mathbf{P}_l$$

Non-linear regression: random forest.



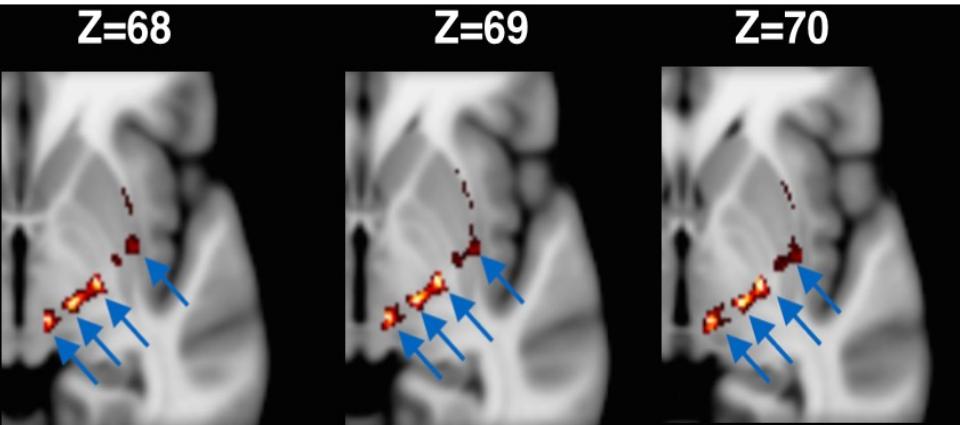
# Super-resolution



# Tractography

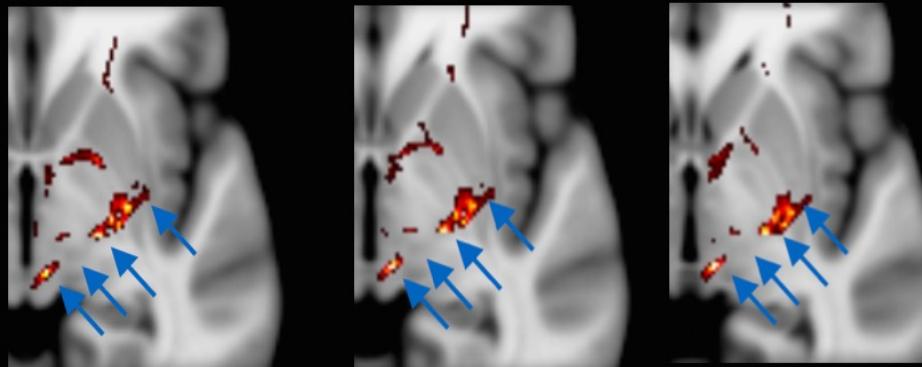
A

Original



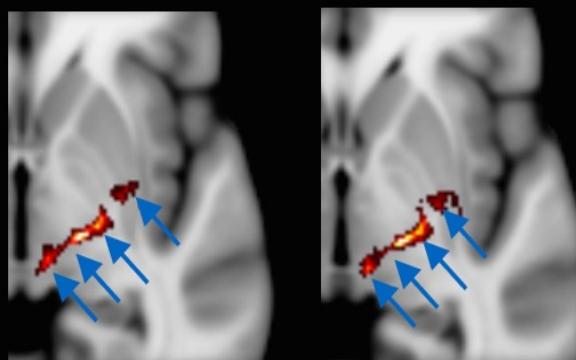
Acquired at  
1.25mm  
resolution

Linear  
Interpolation



Acquired at  
2.5mm  
resolution and  
upsampled to  
1.25mm  
resolution

Random  
Forest  
Regression



Alexander  
NIMG 2017

# Bayesian IQT and deep learning



Tanno MICCAI

2016, 2017

Blumberg MICCAI

2018

Tanno NIMG 2021



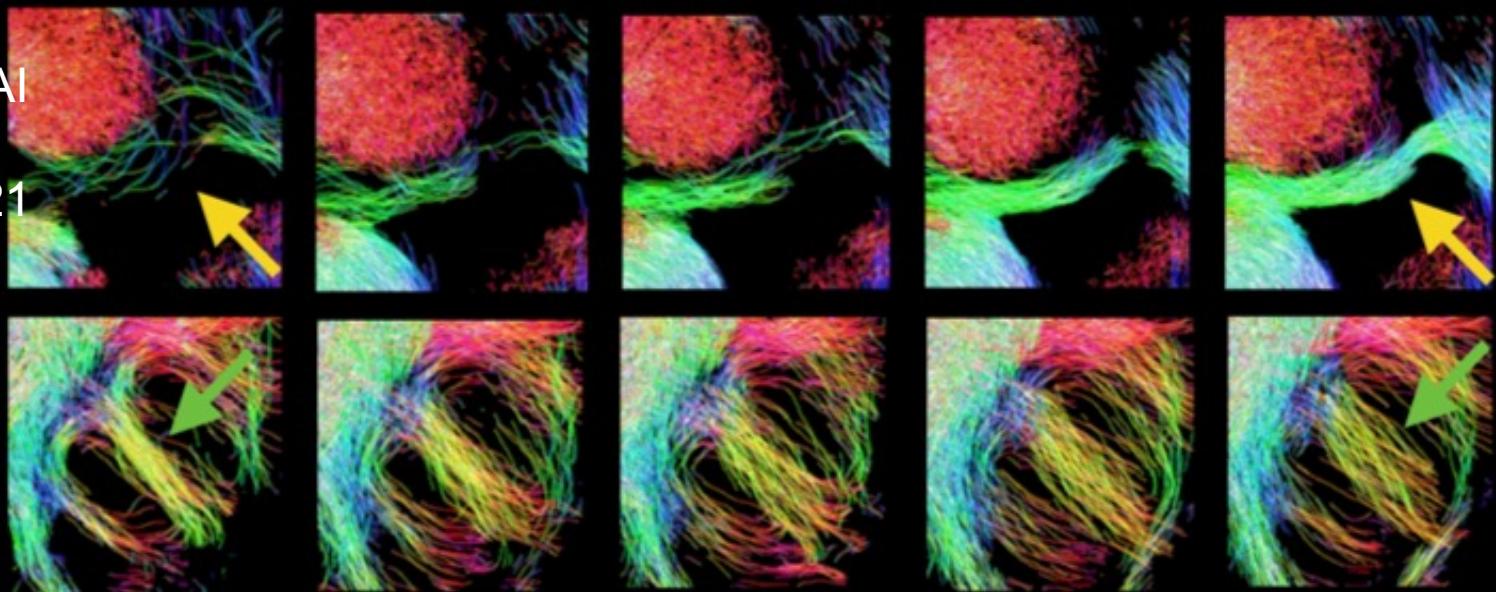
HR

CNN

IQT-RF

Linear Int.

LR



LR Input

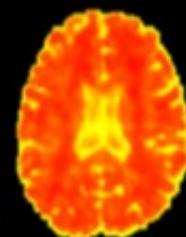
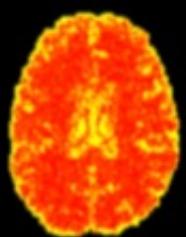
GT

HR Prediction

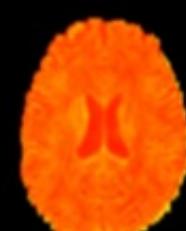
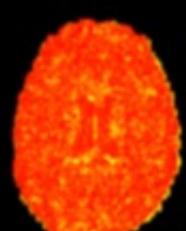
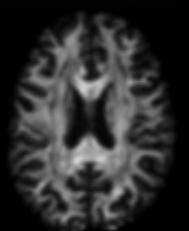
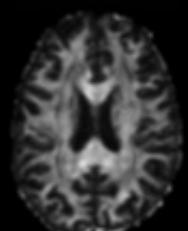
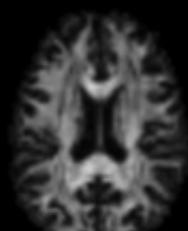
RMSE

Uncertainty

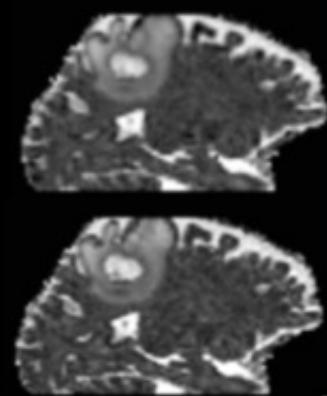
MD



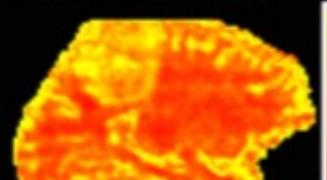
FA



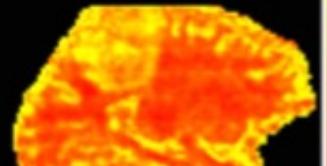
Clinical image



After SR

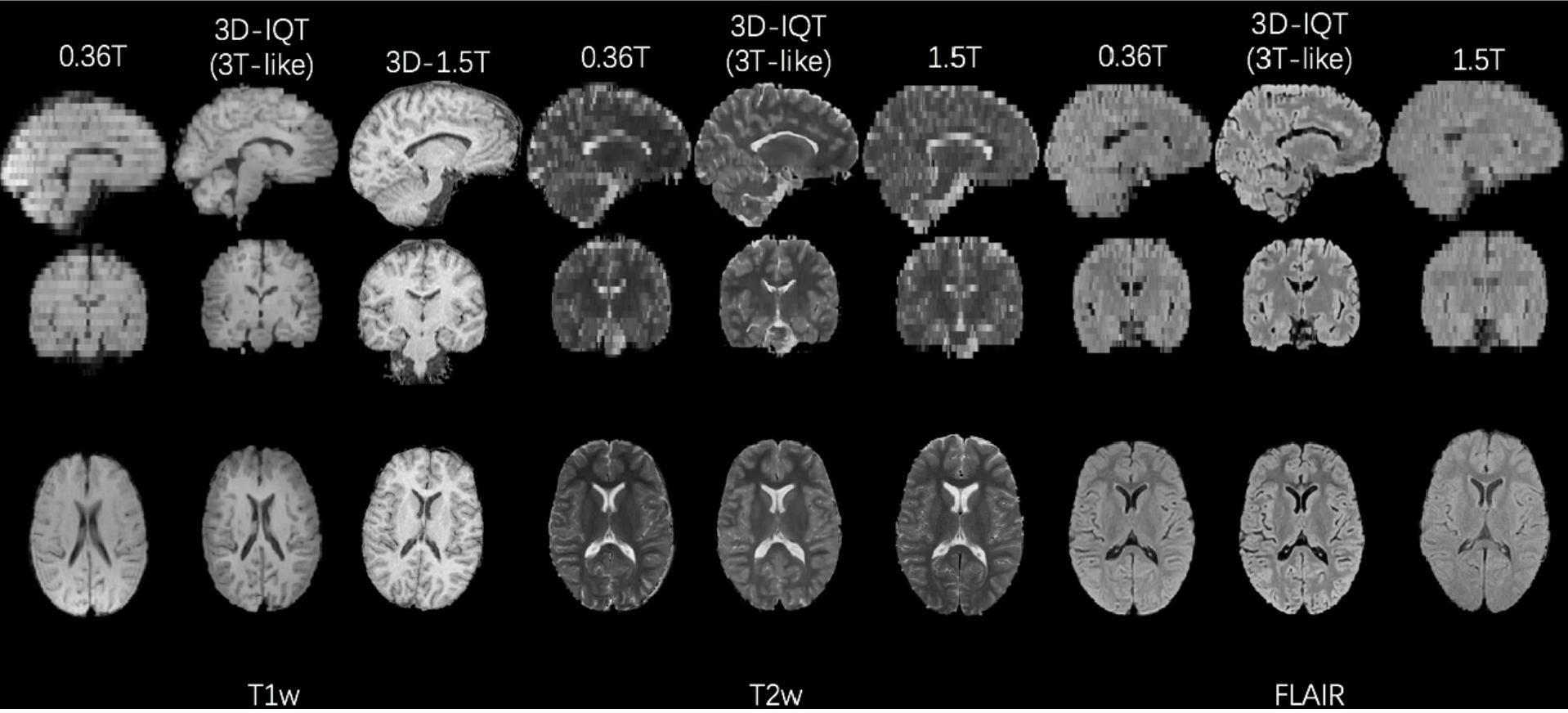


Uncertainty



# Low to high field

Lin ISMRM 2021

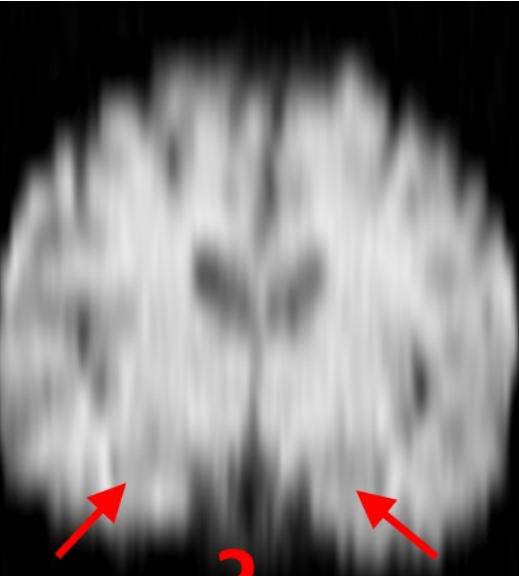


# IQT-Nigeria project

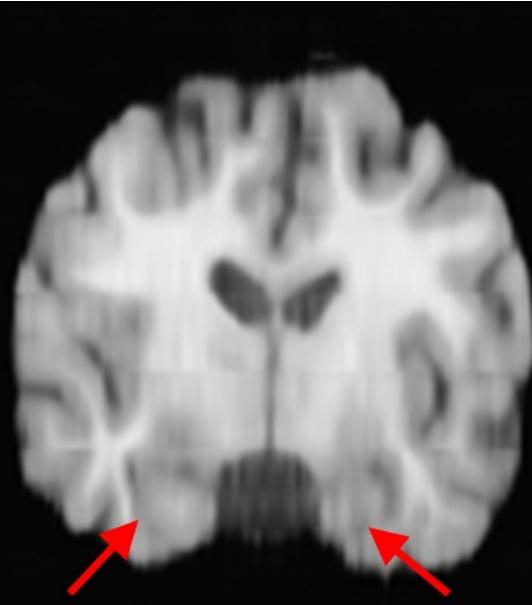


Lin et al MICCAI-MLMIR  
2019

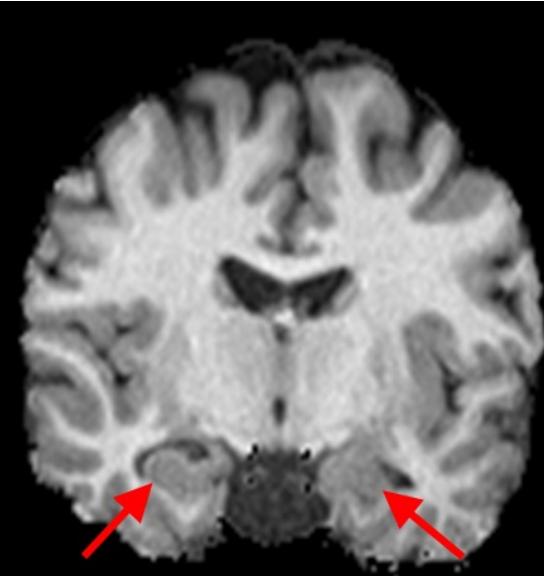
18-year-old epilepsy patient  
with hippocampal sclerosis



LF - simulated



LF - enhanced



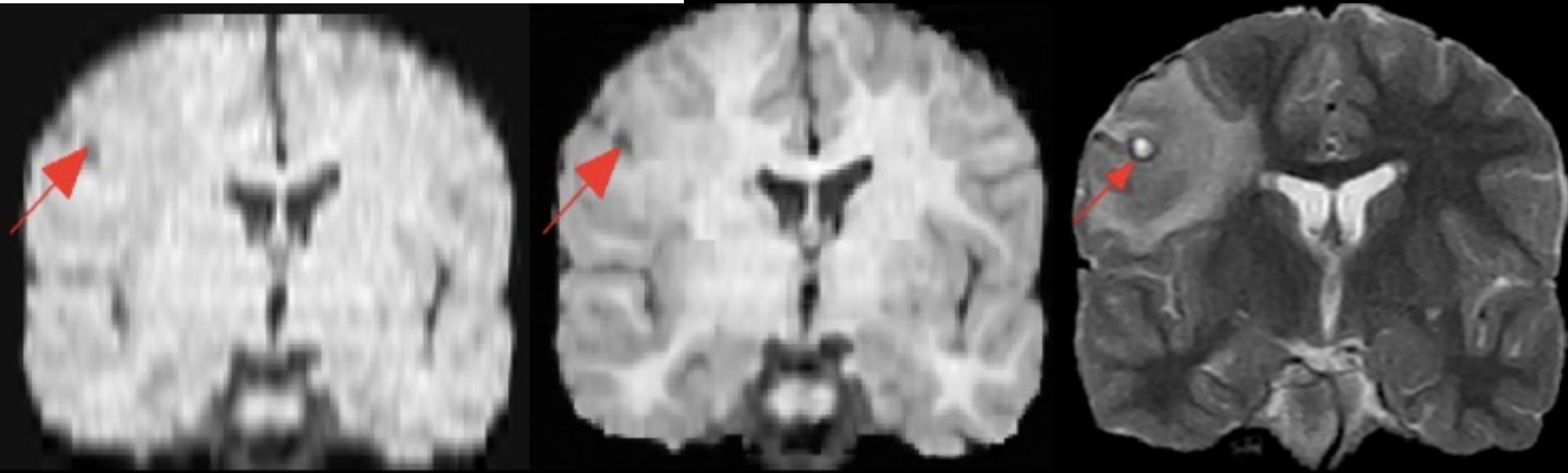
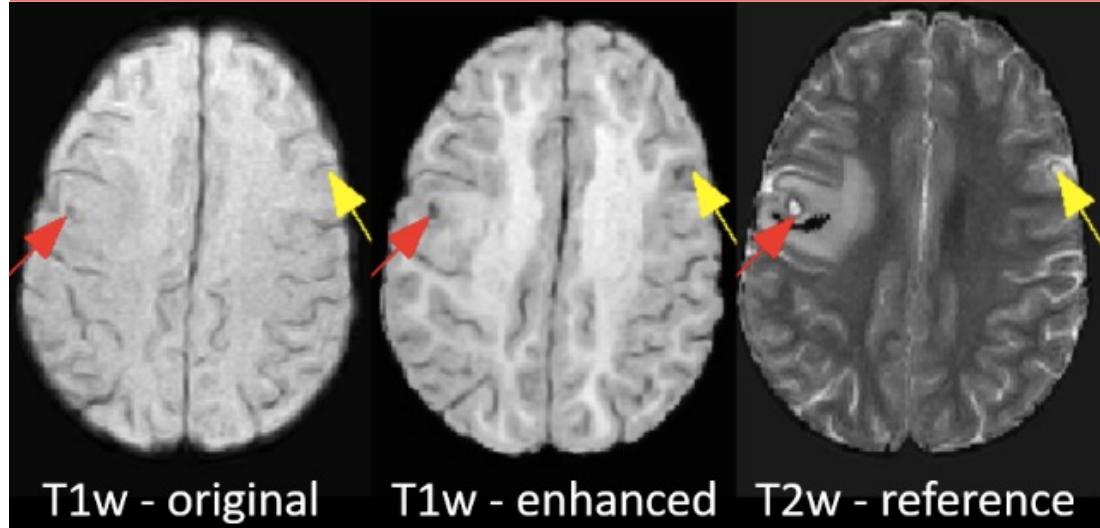
HF - reference

# IQT-Nigeria project



Lin et al MICCAI-MLMIR  
2019

10-year-old epilepsy  
patient with two parietal  
cystic lesions



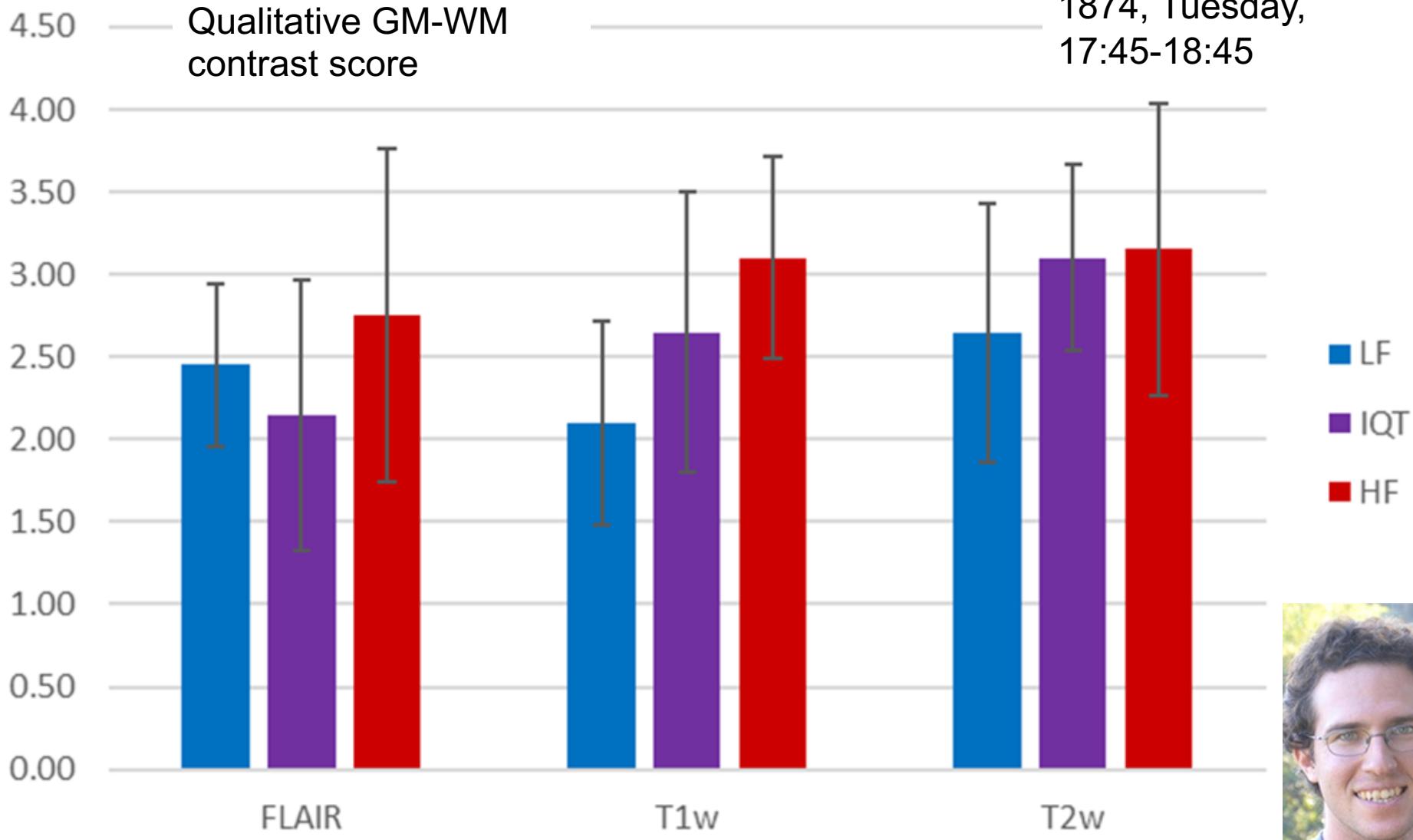
T1w - original

T1w - enhanced

T2w - reference

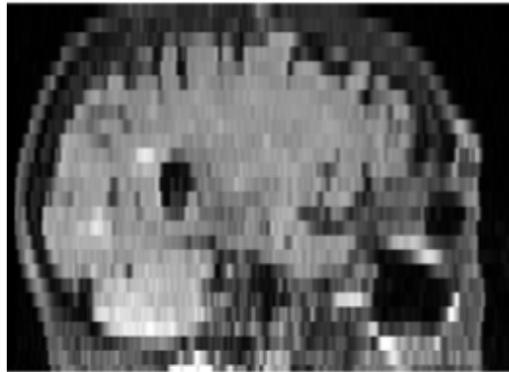
# Clinical evaluation

Figini ISMRM 2022.  
1874, Tuesday,  
17:45-18:45



# SynthSR

Example 1:  
6 mm axial FLAIR



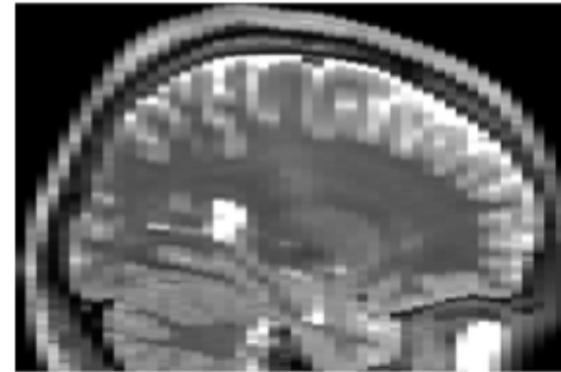
SynthSR

Example 2:  
5 mm sagittal TSE-T1

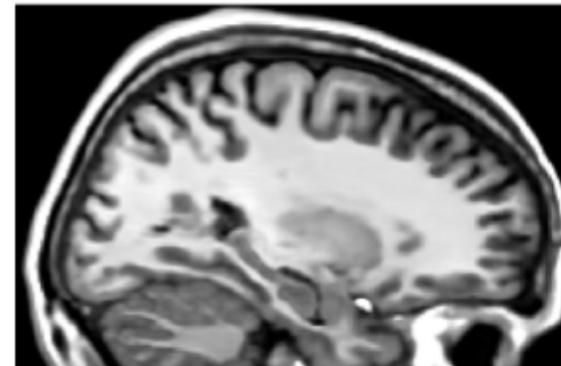
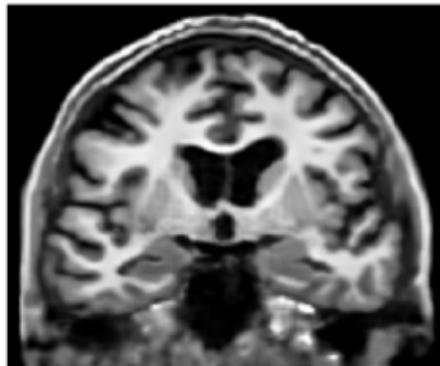
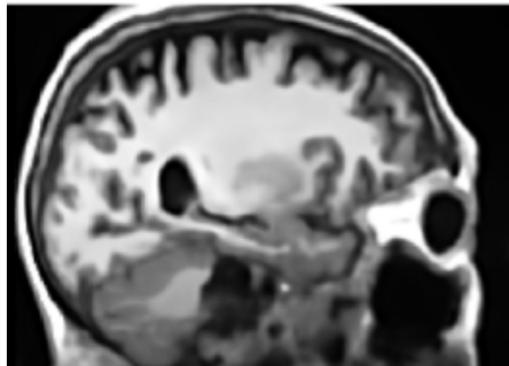


SynthSR

Example 3:  
4 mm coronal T2



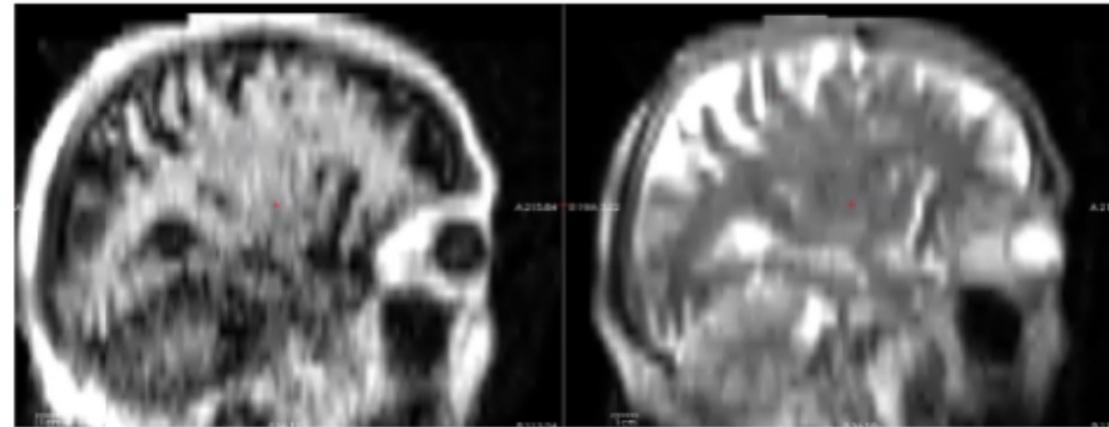
SynthSR



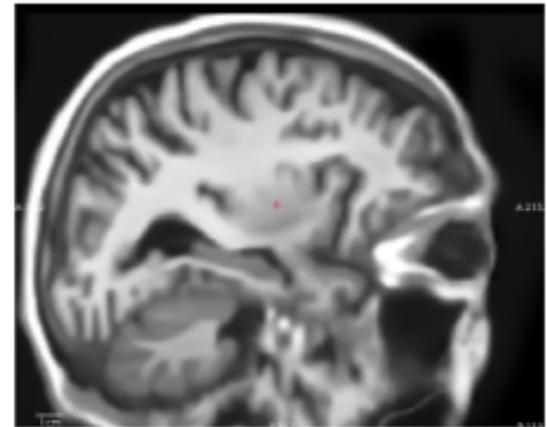
# SynthSR Hyperfine



Iglesias arxiv 2202.03564



Low-field T1w and T2w scans

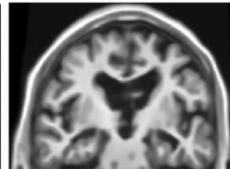
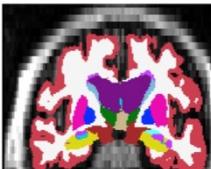
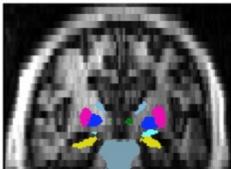


Real MPRAGE and auto. segmentation

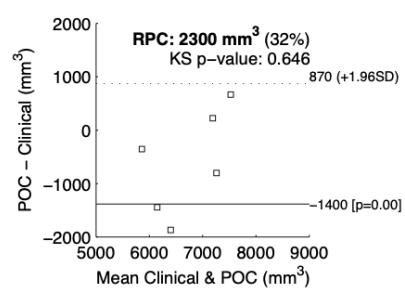
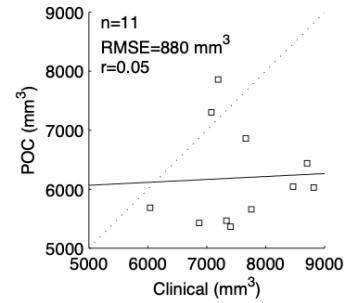
FSL-FAST

SAMSEG

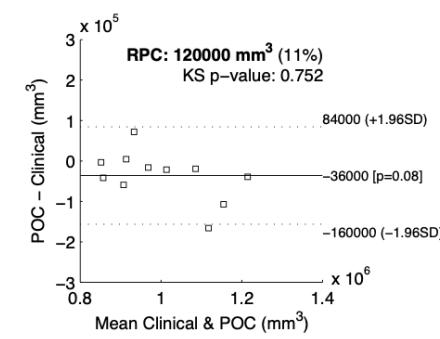
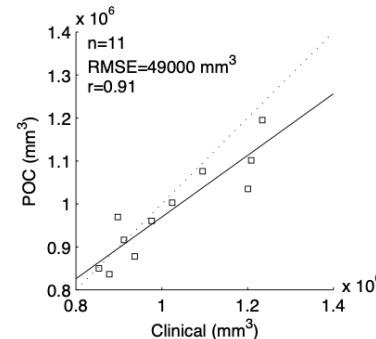
SynthSR and auto. segmentation



Caudate



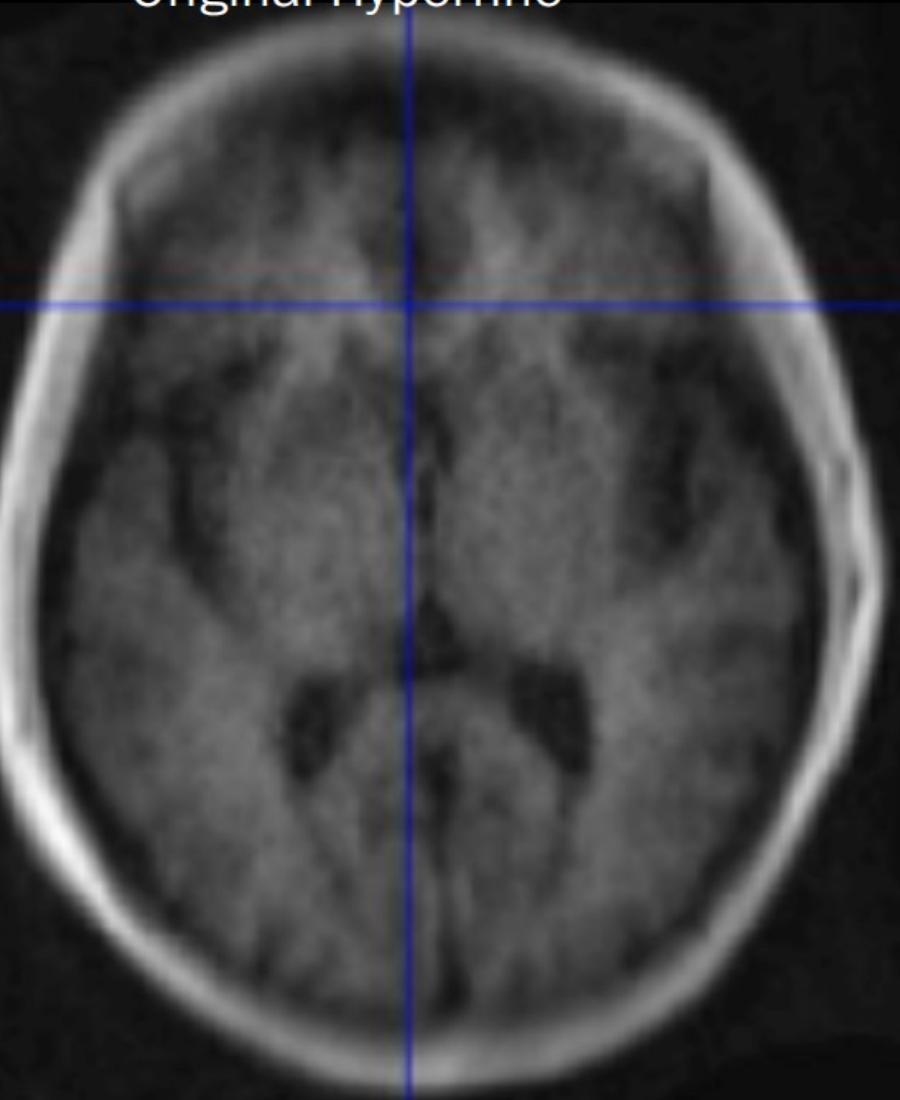
Whole Cerebrum



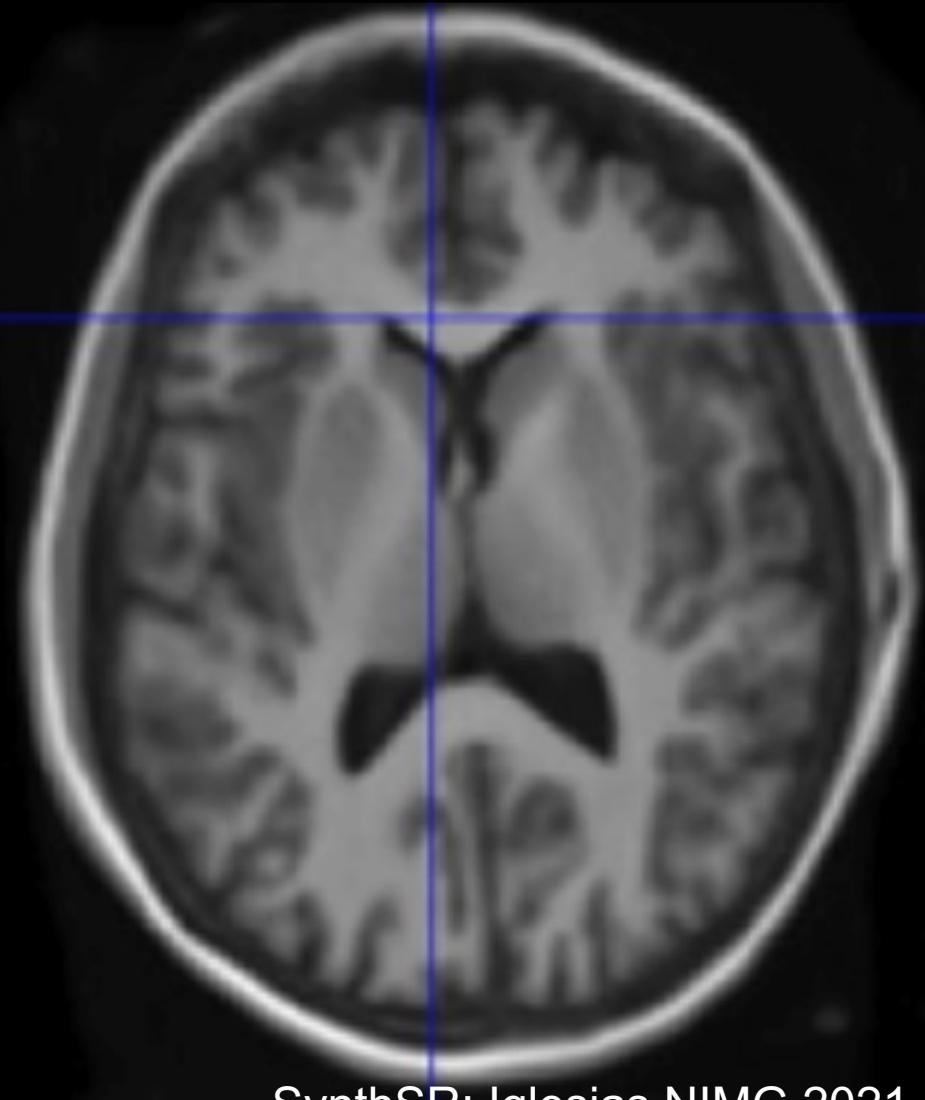
# Hyperfine SynthSR



Original Hyperfine



IQT-enhanced

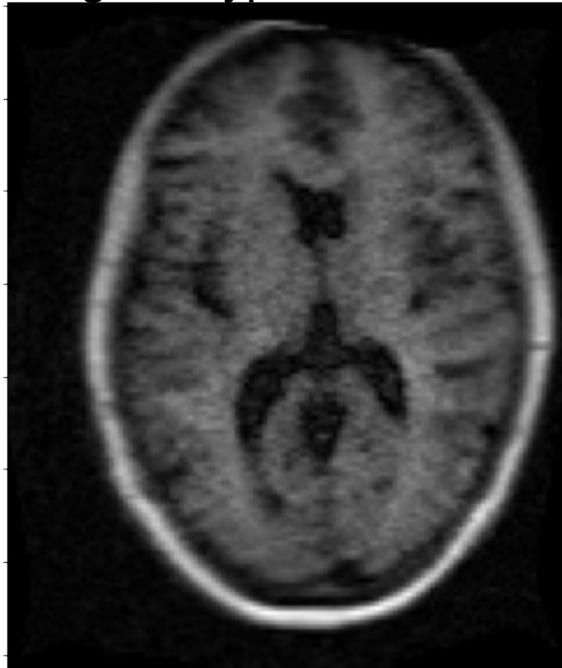


SynthSR: Iglesias NIMG 2021

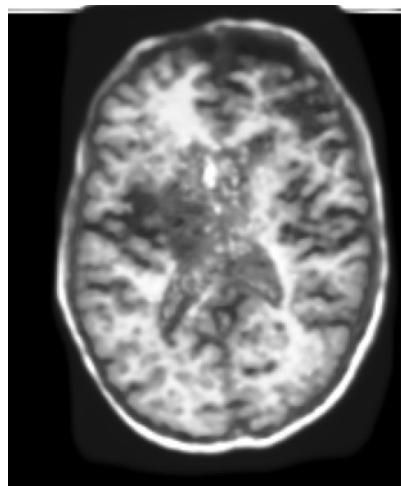
# Hyperfine SynthSR



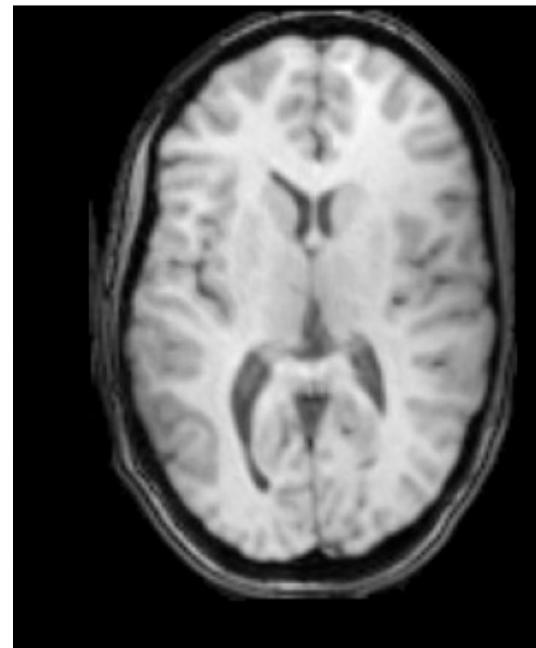
Original hyperfine T1



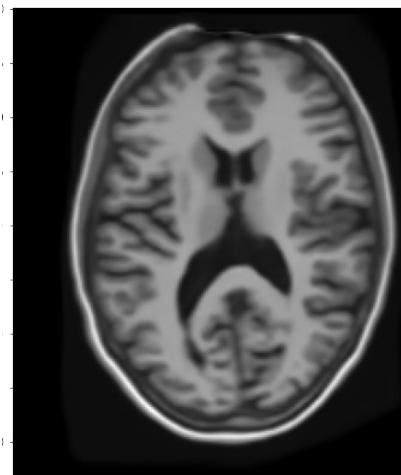
SynthSR (T1 only)



3T Reference



SynthSR (T1 + T2)

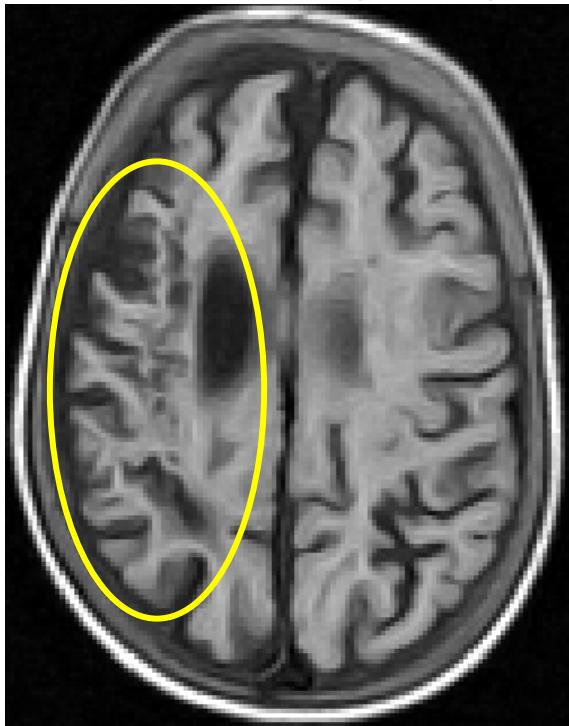


Lisa Ronan

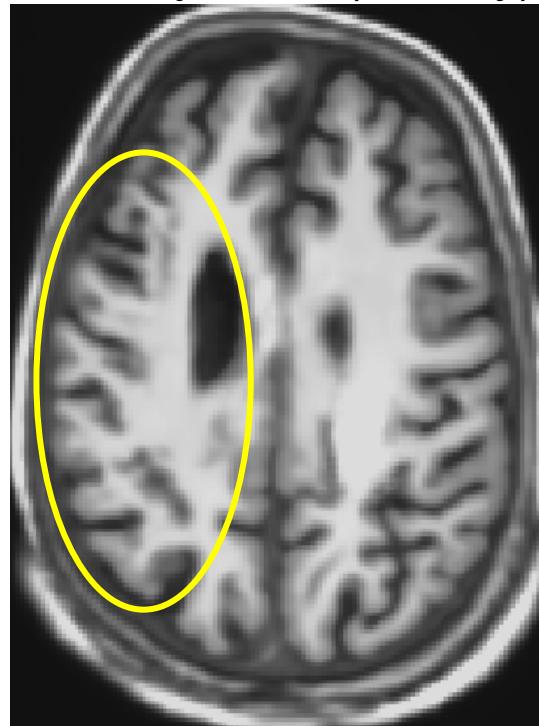
# SynthSR 0.36T lesions



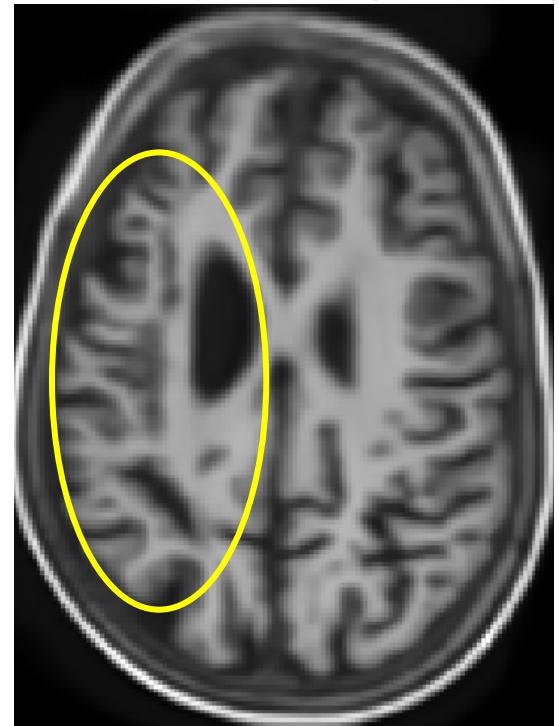
Low-field (0.36T) T1



SynthSR (T1 only)

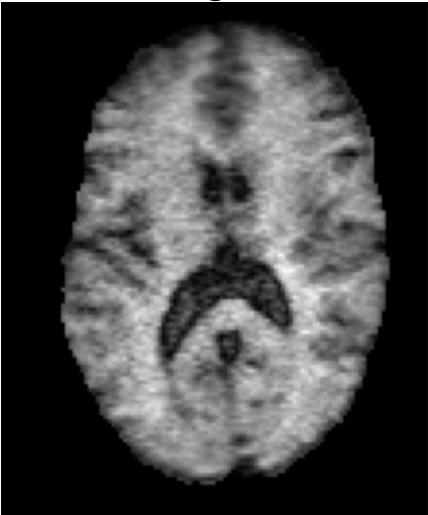


SynthSR (T1 & T2)

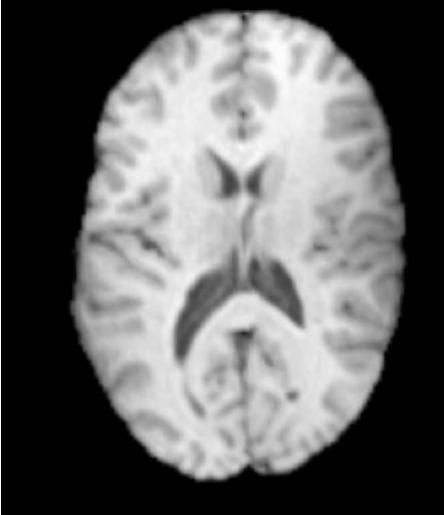


# Current work

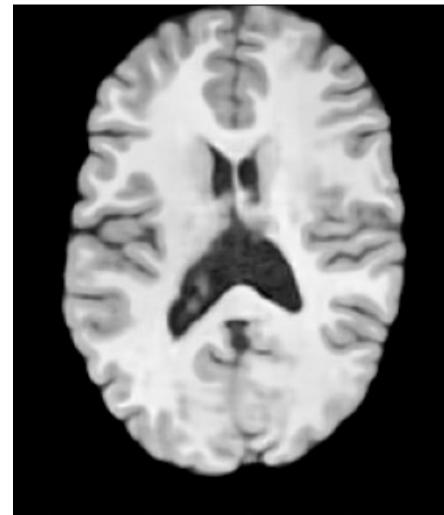
Original T1



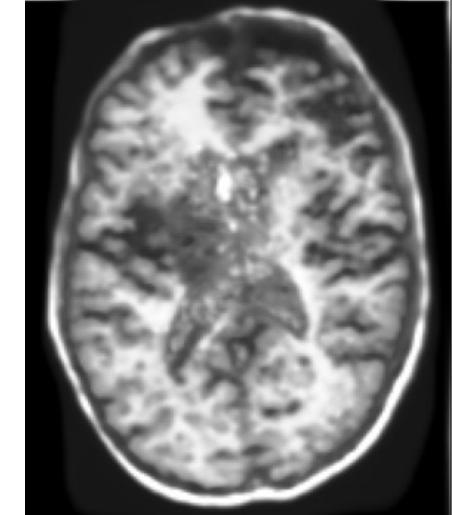
3T Reference



IQT UCL



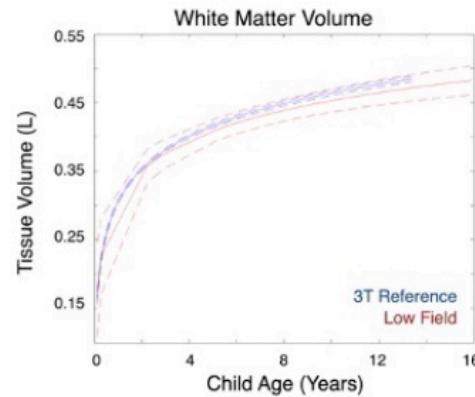
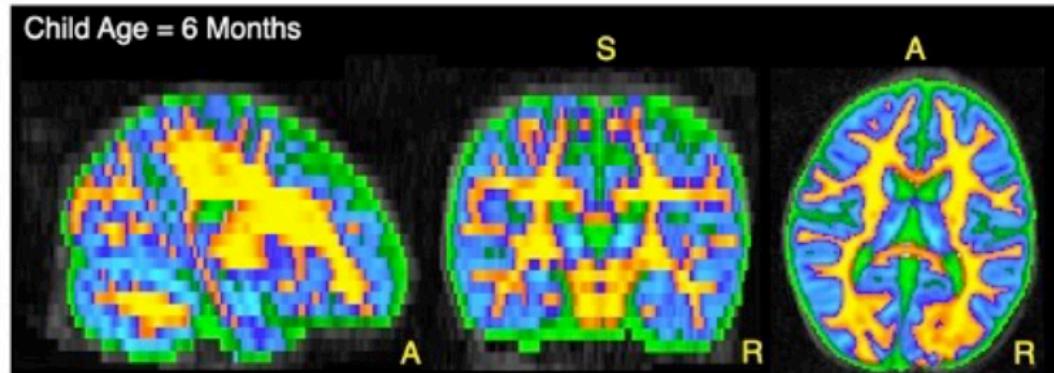
SynthSR (T1)



- ✓ Output 1mm isotropic IQT volume
- ✓ Single input
- ✓ Handles lesions
- ✓ Good tissue contrast
- ✓ Not limited to T1 output



Lisa Ronan



Aim: characterize the child development in the first 1000 days



Kirsten A. Donald

Dima Amso  
William P. Fifer

Aarti Kumar



BROWN Viren D'Sa



Derek K. Jones



Vanja Klepac-Ceraj



Daniel C. Alexander



UNIVERSITY  
OF GHANA

Methodius G. Tuuli



Melissa Gladstone



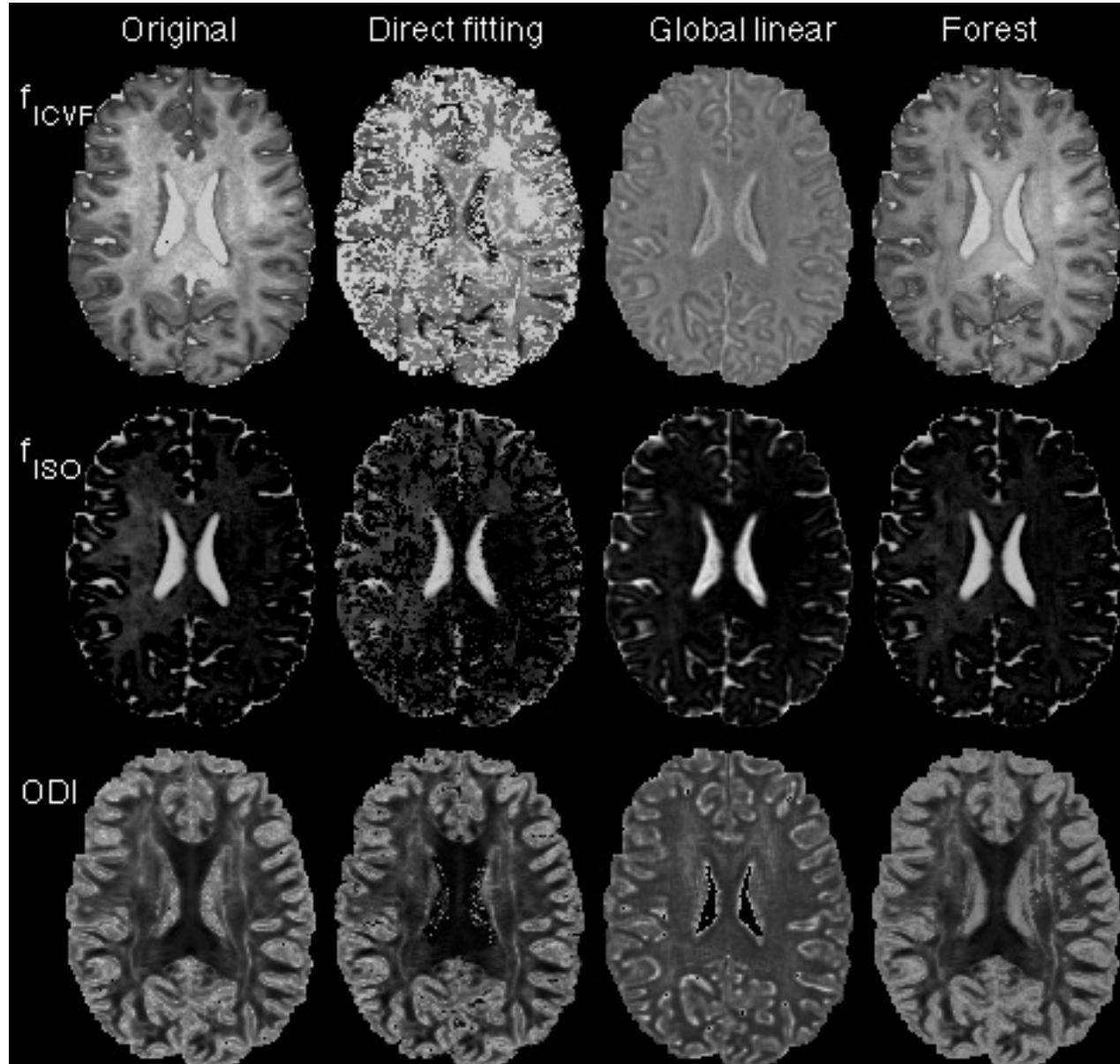
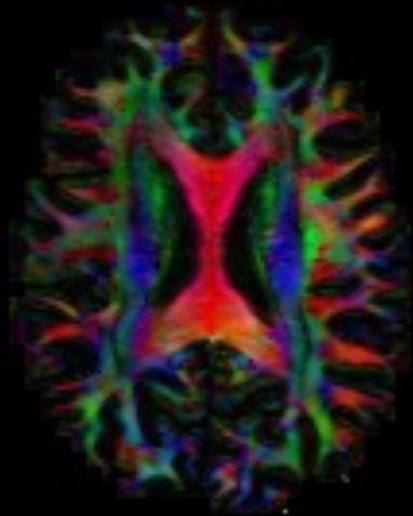
Steve Williams



Laurel Gabard-Durnam

# NODDI reconstruction

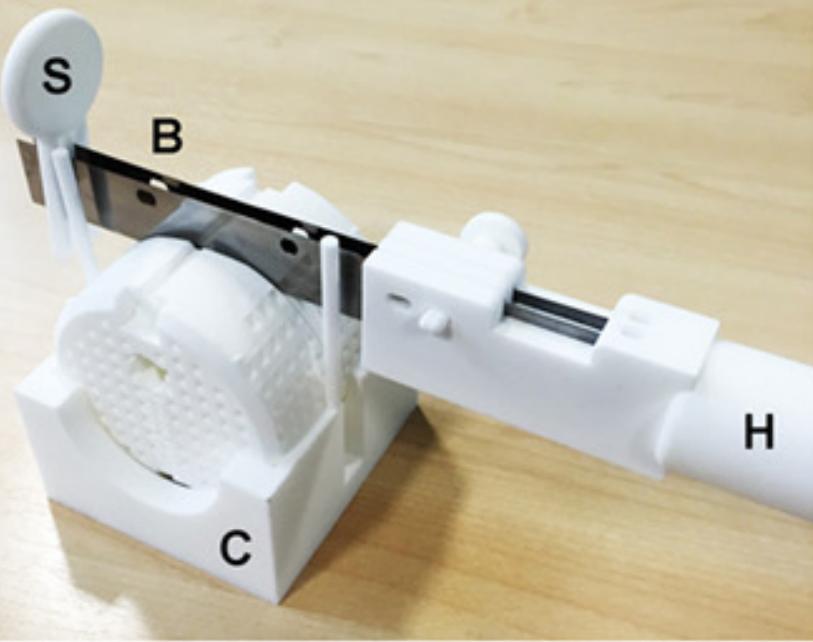
Input:  $b=1000\text{s/mm}^2$  DTI



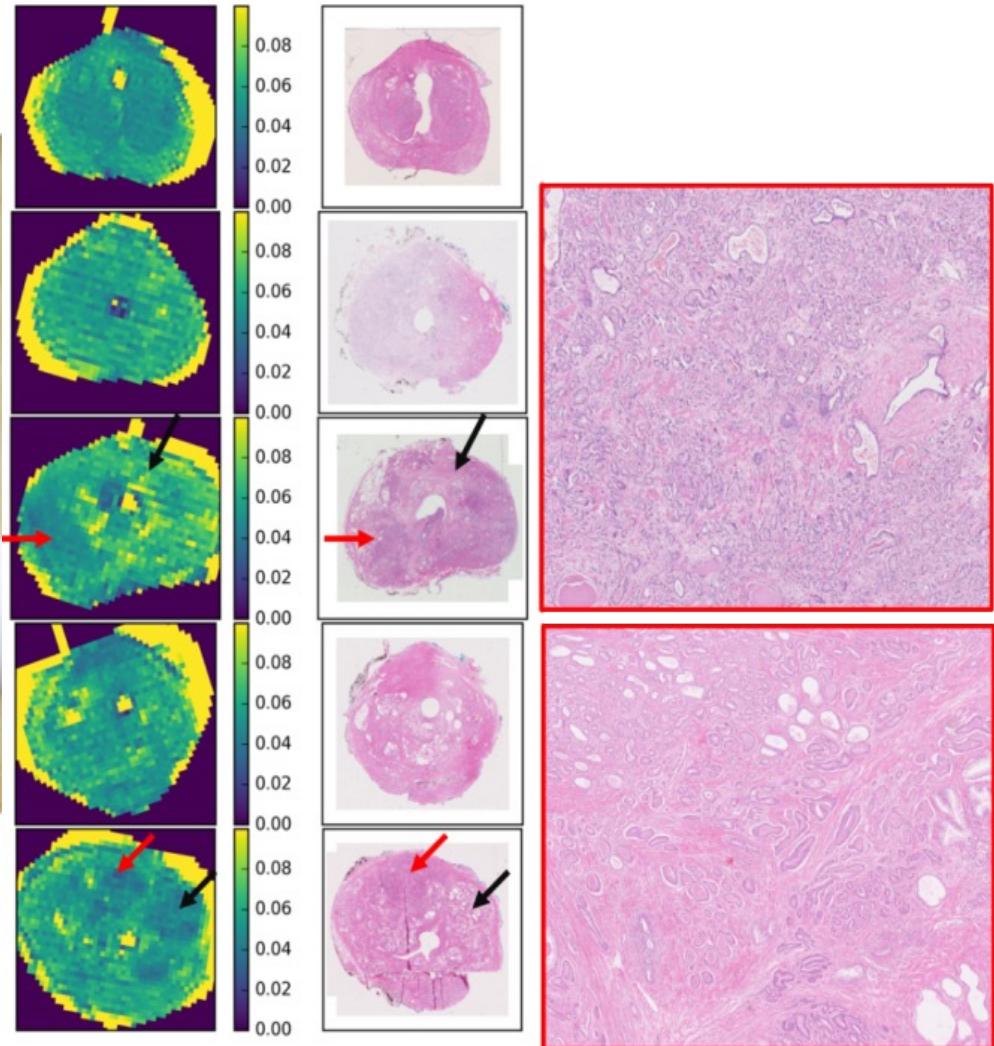
DTI from  $b=1000\text{s/mm}^2$  shell

Train forest using 8 data sets  
and 8 trees.

# MR-histology



Bourne Front. Oncology 2017



# Acknowledgements



- Thanks to all of CMIC: <http://cmic.cs.ucl.ac.uk>
- Many collaborators...
- And various funders:



**wellcome**



**cm1c**

Centre for Medical Image Computing

Horizon  
2020



*National Institute for  
Health Research*

