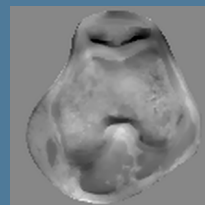
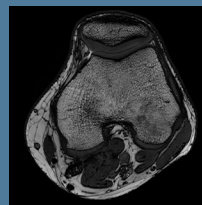


677 On the Feasibility of Quantitative Susceptibility Mapping for Trabecular Bone Volume Density Mapping at 3 T



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Declaration of Financial Interests or Relationships

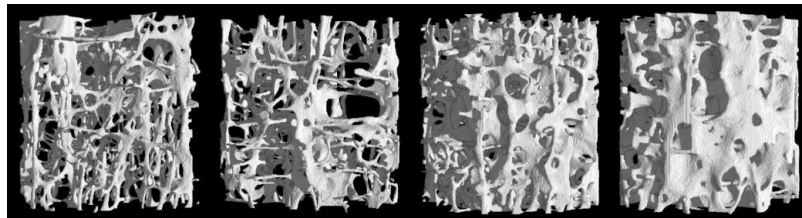
Speaker Name: **Maximilian N. Diefenbach**

I have the following financial interest or relationship to disclose with regard to the subject matter of this presentation:

Company Name: **Philips Healthcare**

Type of Relationship: **Grant Support**

Trabecular bone imaging



- Trabecular bone imaging has a high clinical significance for predicting fracture risk in patients with osteoporosis [1]
- High-resolution trabecular bone imaging previously applied in many distal sites and in the proximal femur with very good correlation with failure load [2,3], but not possible in many skeletal sites (e.g. spine)
- R_2^* mapping has been previously proposed as an alternative for indirectly measuring trabecular bone density [4]

QSM for bone

- Quantitative susceptibility mapping (QSM) has been recently emerging for mapping diamagnetic and paramagnetic substances, primarily in the brain [6]
- Bone is diamagnetic and the magnetic susceptibility difference between cortical bone and water/fat can be captured using magnetic susceptibility measurements [4]
- Recent reports attempted to use QSM combined with ultra-short echo time (UTE) imaging for mapping the susceptibility of cortical bone [7, 8]

Research Question:

Can changes in the **trabecular bone** density be detected by **Quantitative Susceptibility Mapping** at 3T?

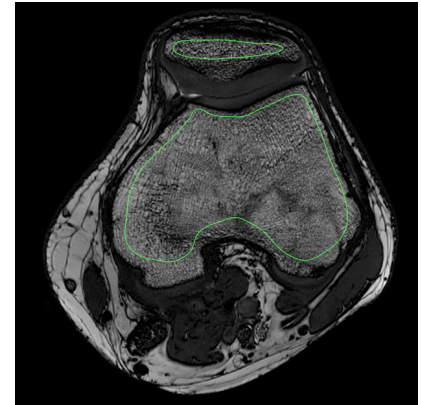
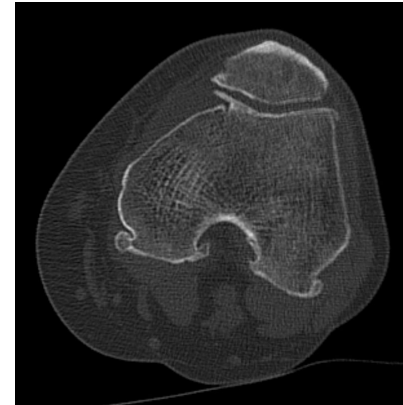
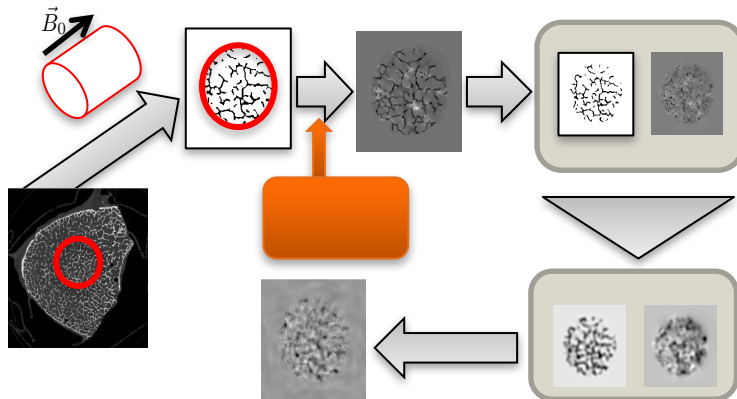
The research question was addressed by 2 methods.

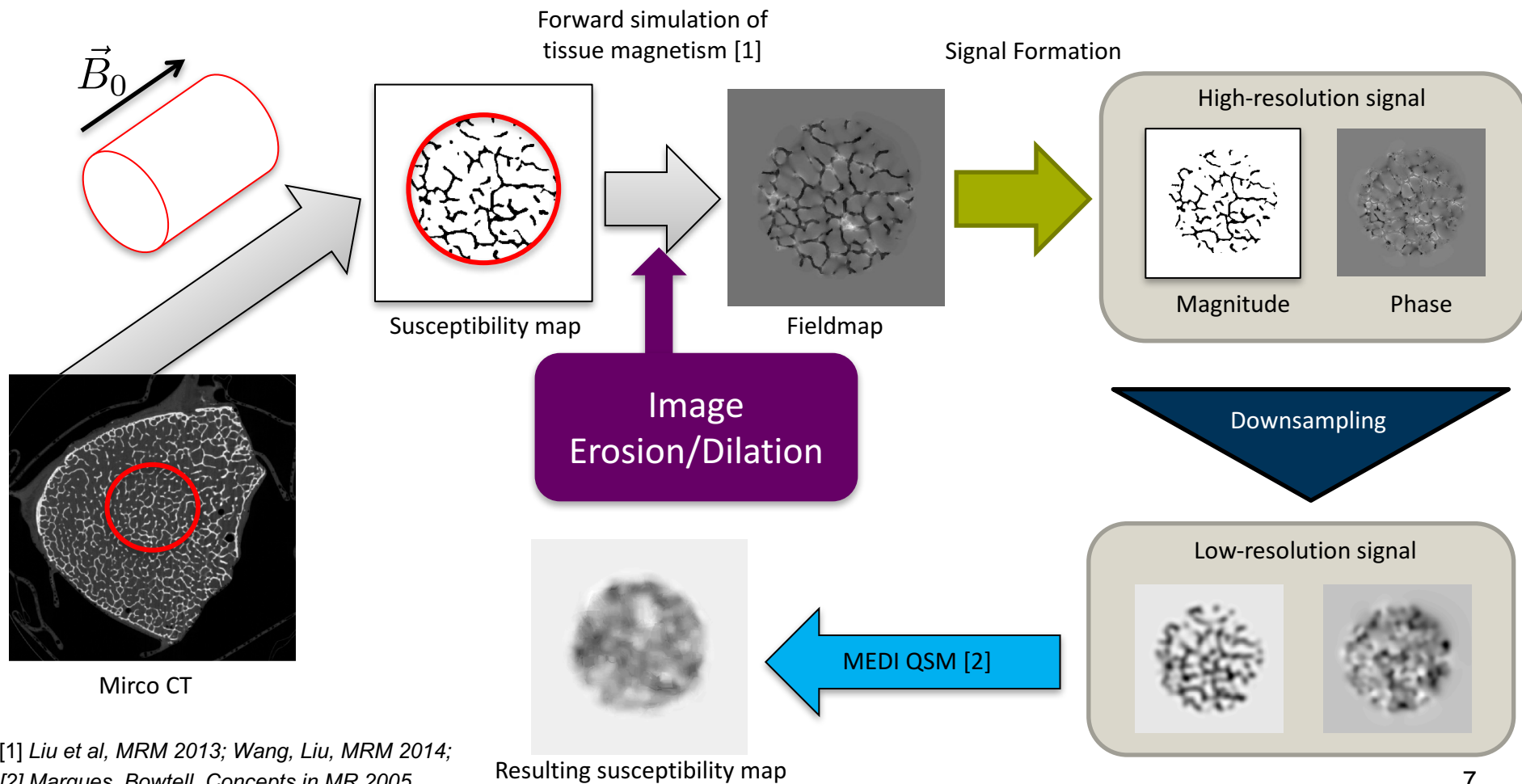
1.

Numerical
Simulations

2.

In Vivo
Measurements





Erosion/Dilation Parameters

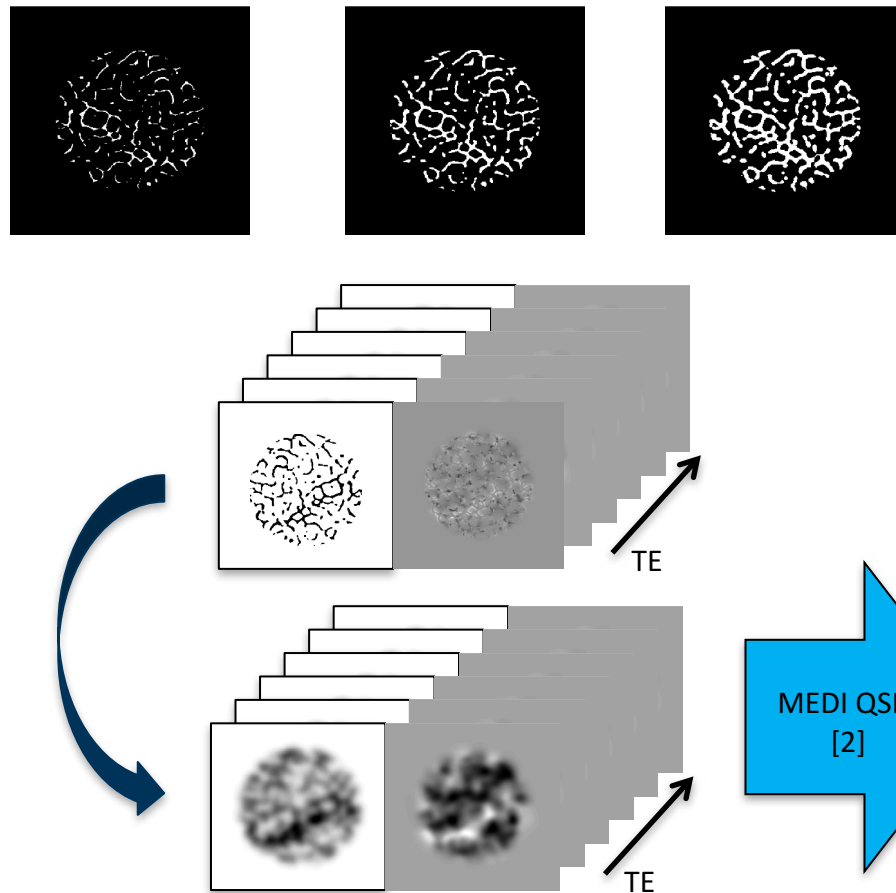
Neighborhood	3D 6-connected pixels
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Signal Formation Parameters

Number of echoes	6
TE1/delta TE	1/3 ms
Susceptibility difference inside/outside of cylinder	-3 ppm (chi bone -12ppm, chi water -9ppm)

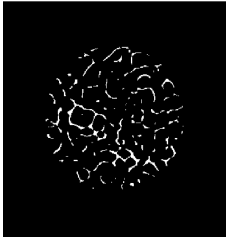
Downsampling Parameters

Resolution before downsampling	0.055 mm isotropic
Resolution after downsampling	2 mm isotropic

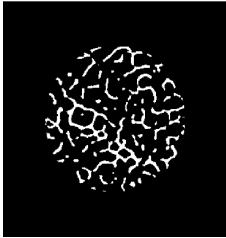


Bone volume : total volume (BV/TV)

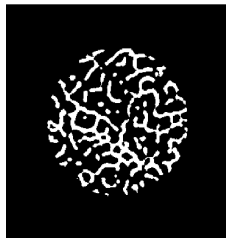
~ 0.08



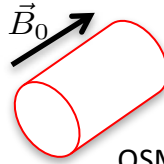
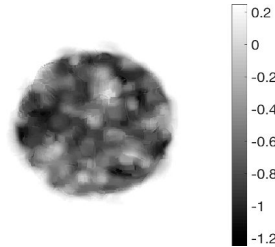
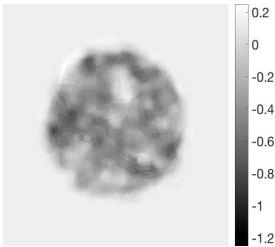
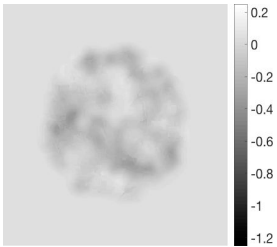
~ 0.19



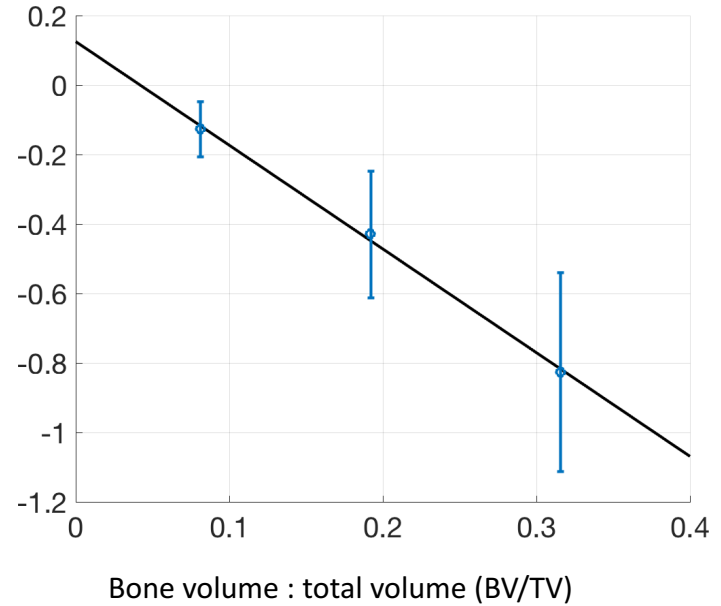
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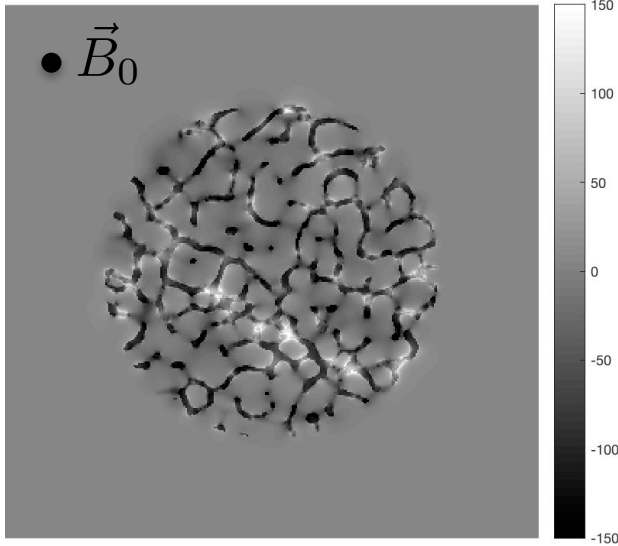
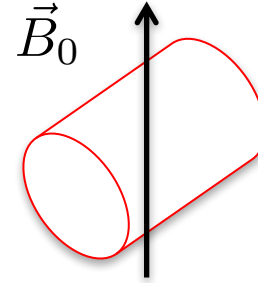
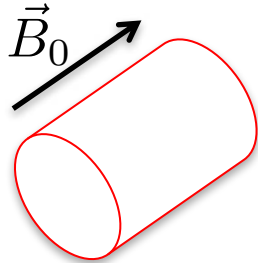
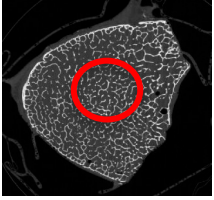


QSM susceptibility maps in [ppm]

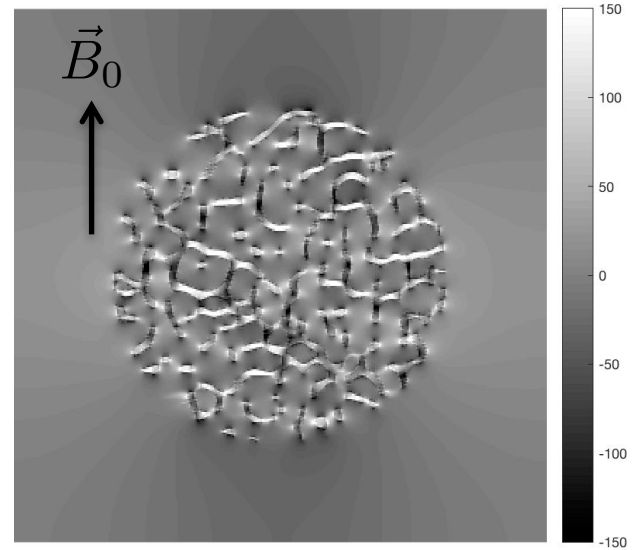


QSM mean susceptibility values inside the cylinder in [ppm]
(referenced to values outside the cylinder)





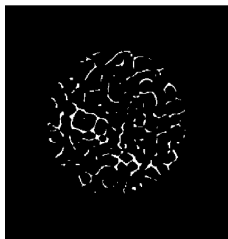
Fieldmap / [Hz]



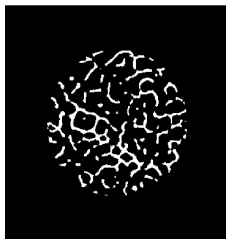
Fieldmap / [Hz]

Bone volume : total volume (BV/TV)

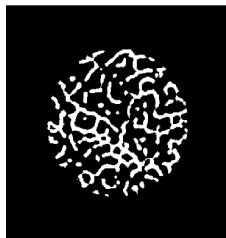
~ 0.08



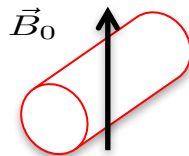
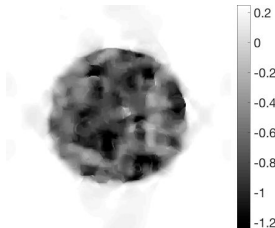
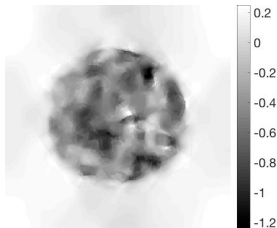
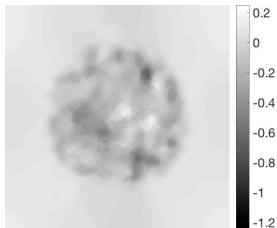
~ 0.19



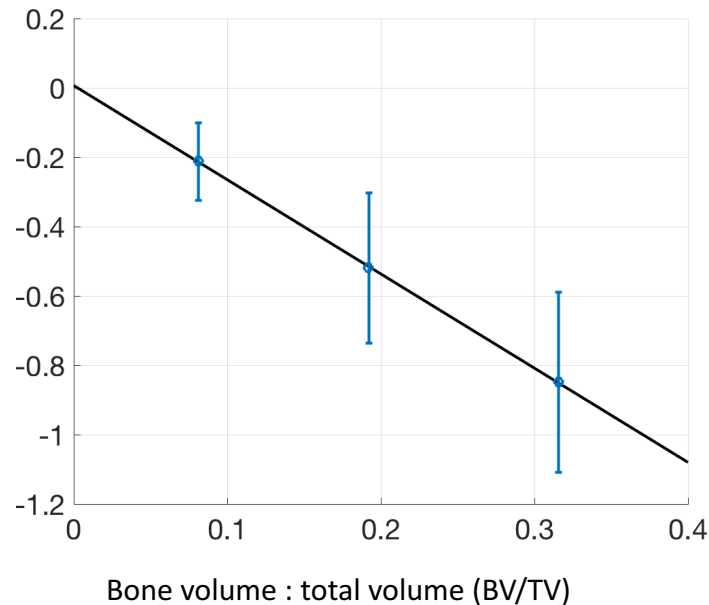
~ 0.32



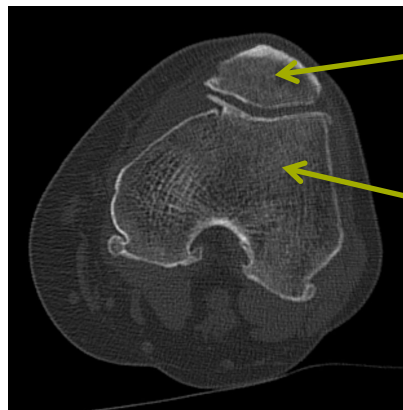
QSM susceptibility maps in [ppm]



QSM mean susceptibility values inside the cylinder in [ppm]
(referenced to values outside the cylinder)



2. In Vivo Measurements in the Knee

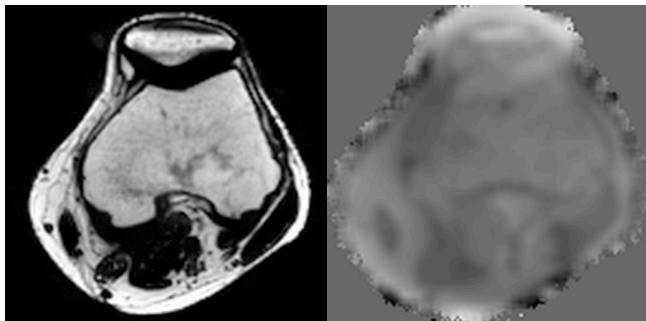


Patella

Femur

CT image

Low resolution scan



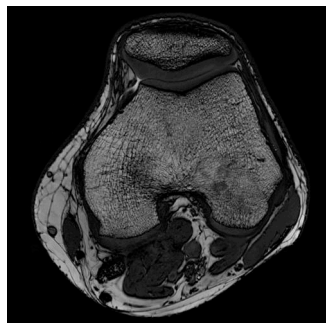
Low resolution scan parameters

Type	Gradient echo
Readout	Monopolar
Number of echos	12 (3 interleaves a 4 echos *)
TE1/delta TE	1.7/0.9 ms
Voxel size	1 mm isotropic



QSM

High resolution scan



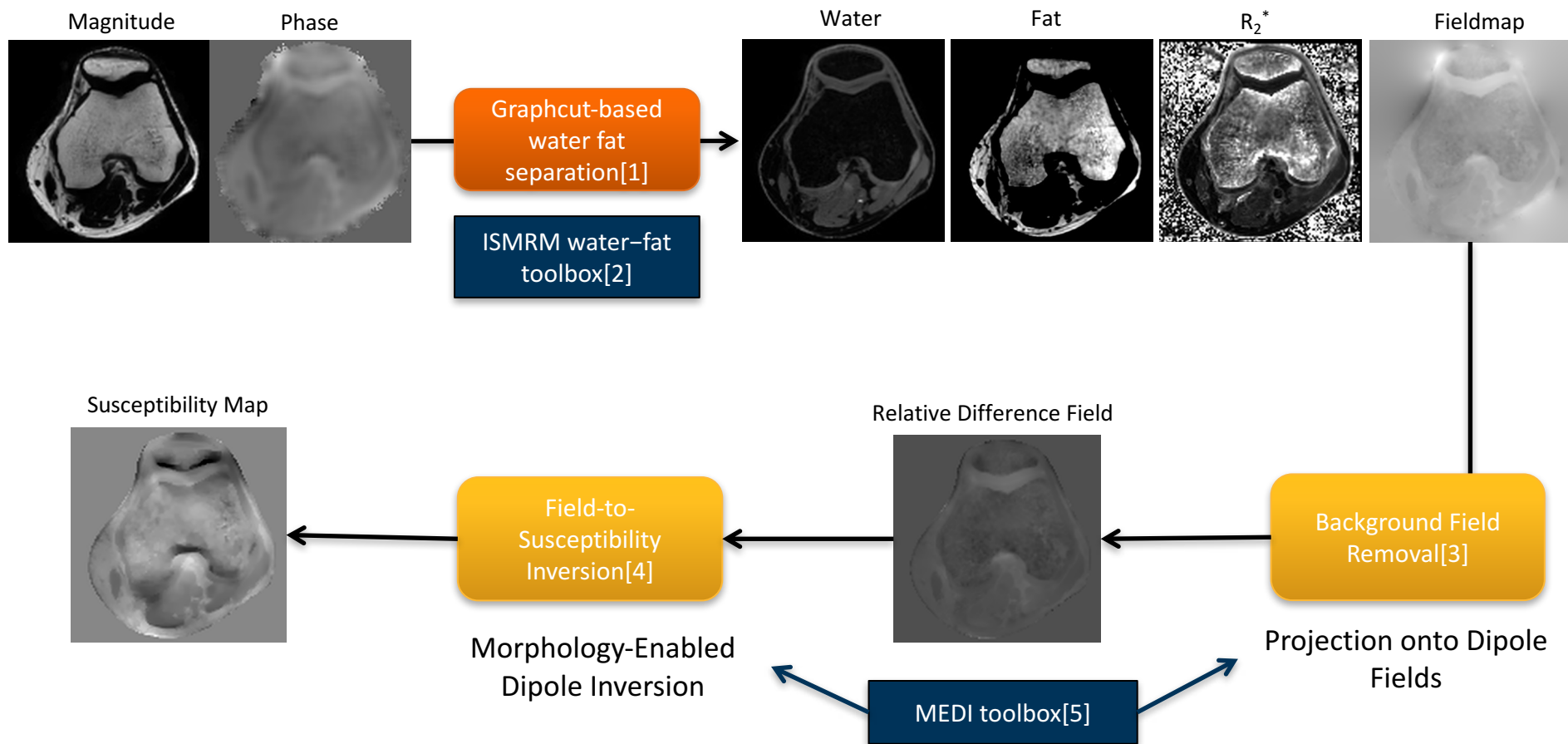
High resolution scan parameters

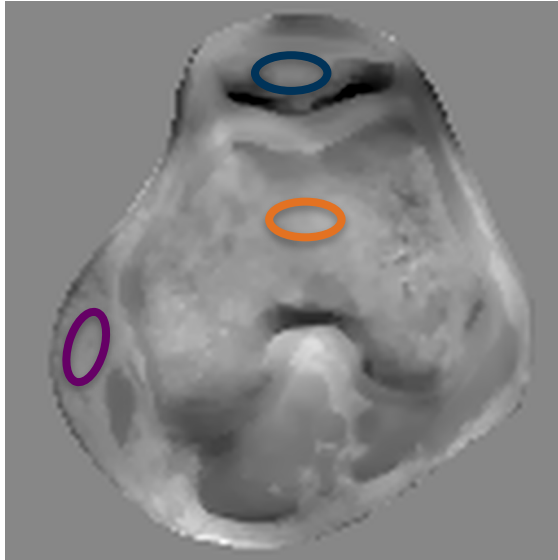
Type	Balanced SSFP with 2 phase cycles
TE	3.4 ms
Voxel size	[0.3, 0.3, 0.9] mm



Bone volume :
total volume
(BV/TV)

* Ruschke et al. ISMRM 2015 abstract 3657

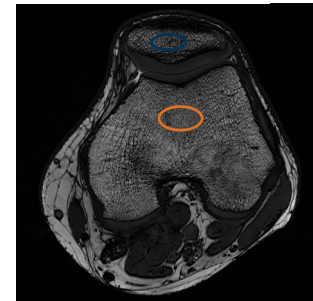
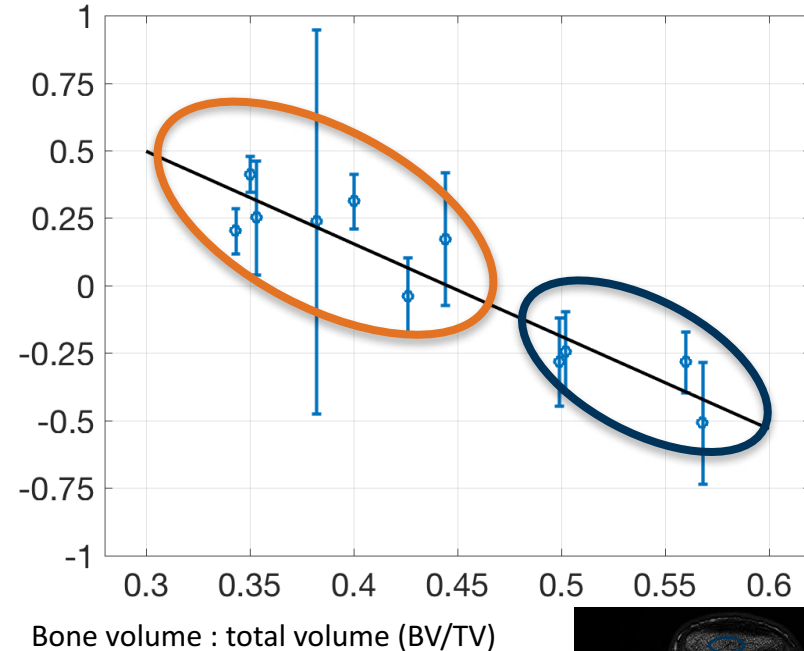




ROI analysis:

- ROIs are selected in regions without red bone marrow
- ROI values are referenced to fat ROI values

QSM susceptibility values in [ppm]
(referenced to fat ROI values)



Limitations:

- Effect of regions with zero MR signal (cortical bone) on QSM.
- Susceptibility of bone was previously reported between -12 to -8 ppm [3].
- Only an empirical threshold was used to obtain the BV/TV inside the knee [4].
- Need for robust susceptibility referencing.

Summary:

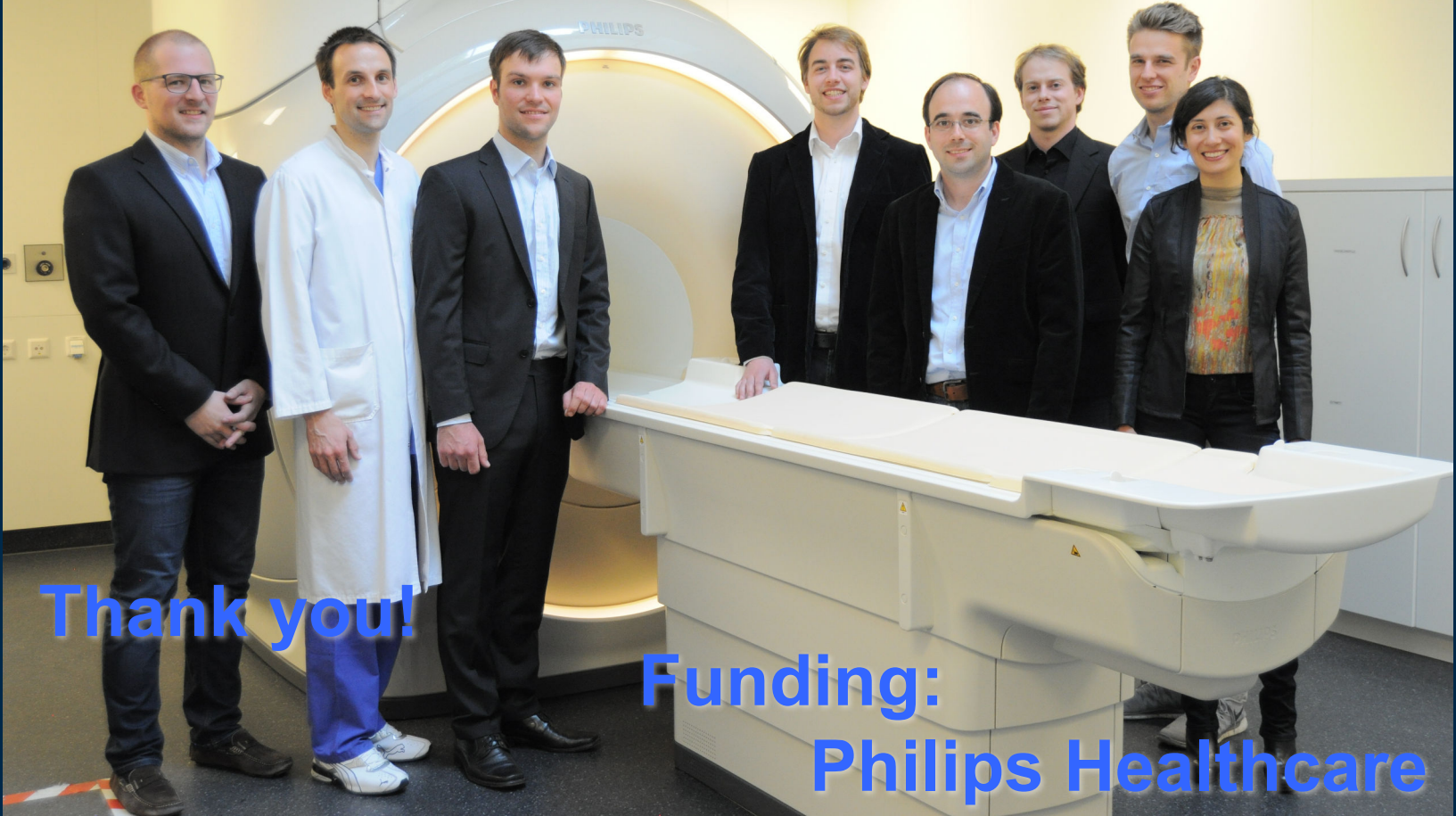
Can changes in the **trabecular bone** density be detected by **Quantitative Susceptibility Mapping** at 3T?



Preliminary results hint at **linear relation** between **BV/TV** and **mean susceptibility** in **trabecular bone**:

- A 10% difference in BV/TV resulted in a ~ 0.3 ppm susceptibility increase.
- Observed range of values are of the order what is currently measured in brain QSM. [1]

Acknowledgements



Thank you!

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