

Direct model-based reconstruction for high-resolution whole-brain DCE- MRI

Yi Guo

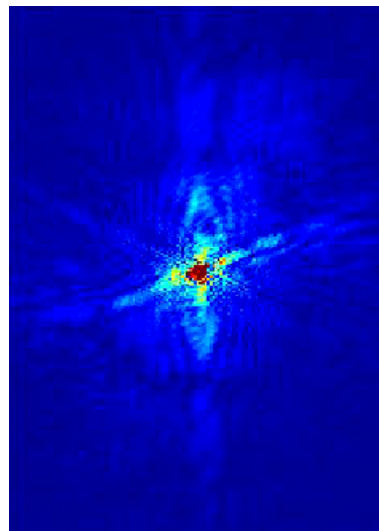
MHI pitch presentation



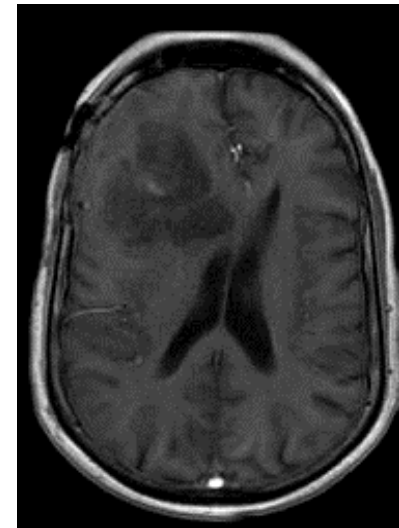
Magnetic Resonance Imaging (MRI)

- MRI is a noninvasive medical imaging tool to produce 3D images using multiple magnetic fields.
- Dynamic Contrast Enhanced (DCE) MRI acquires a series of images to capture the dynamic changes during a contrast injection
 - Essential to evaluate brain tumor and other abnormality

Nyquist sampling
in MRI raw data
space (k-space)



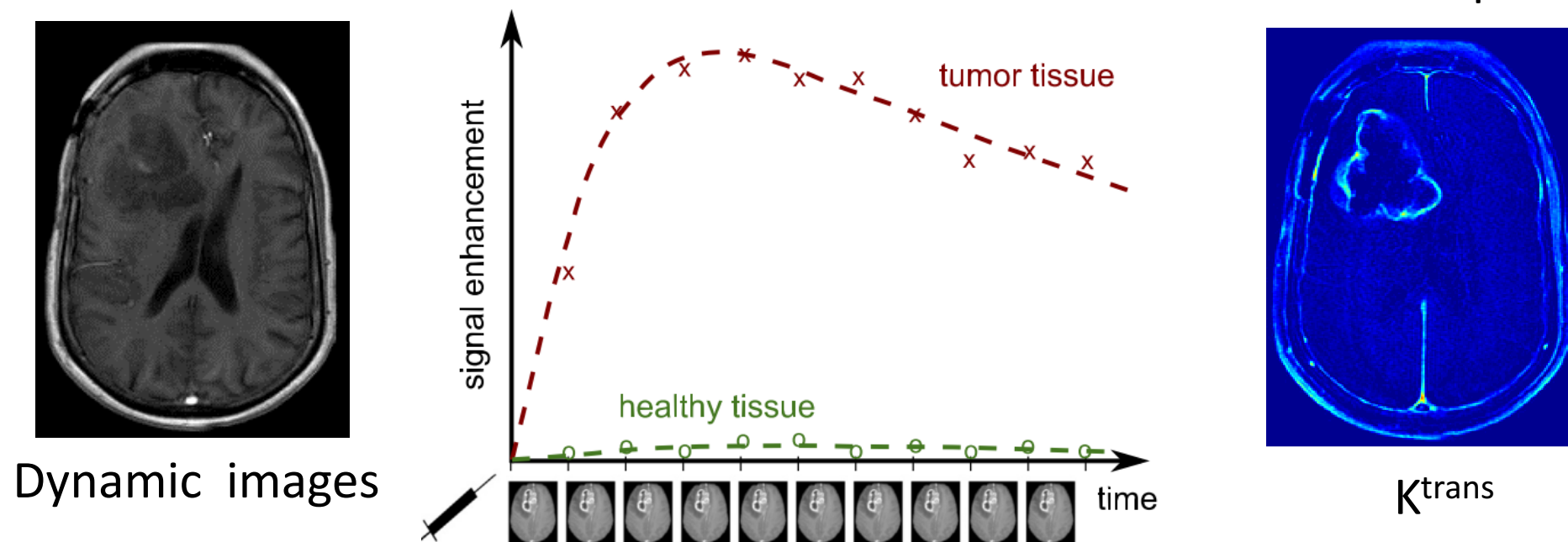
FFT



Dynamic
Contrast
Enhanced
MRI

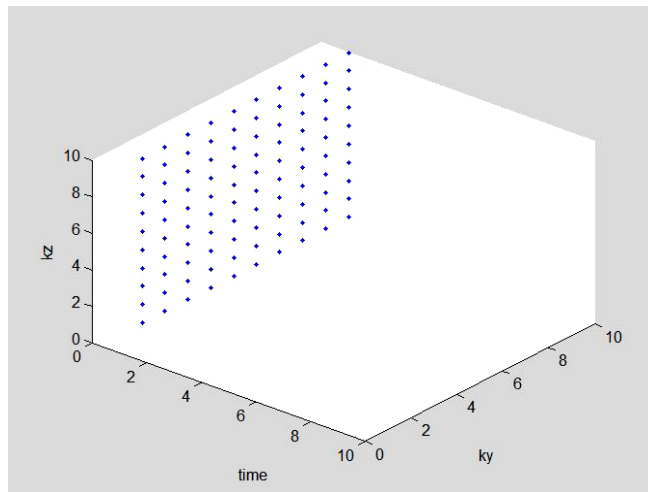
Tumor evaluation using DCE-MRI

- Tumor severity evaluation: important pathological information from tracker-kinetic (TK) maps (K^{trans} , v_p , v_e etc.).

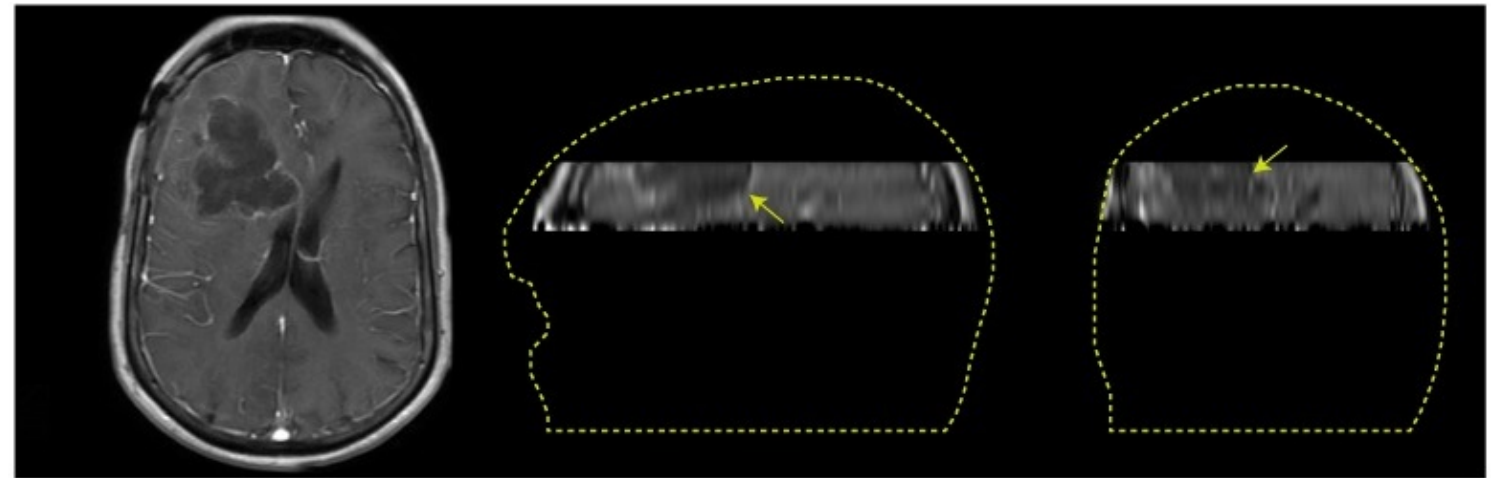


Limited coverage and resolution for conventional DCE-MRI

- 5s temporal resolution, Nyquist sampling (used clinically)
 - > 7 slices, $0.9 \times 1.3 \times 7.0 \text{ mm}^3$ in plane resolution



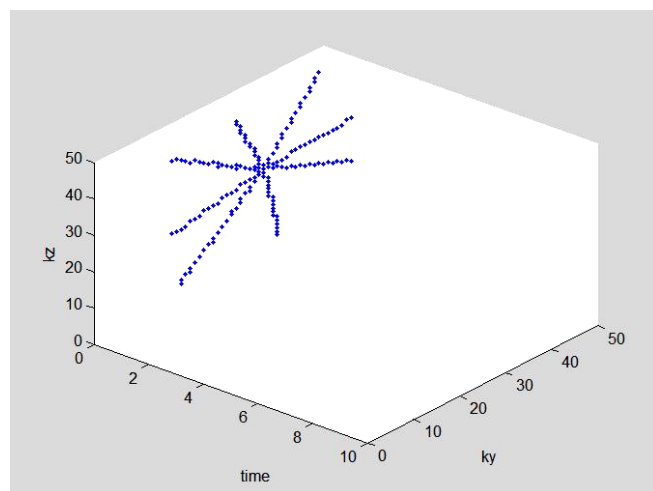
Cartesian **Nyquist** sampling



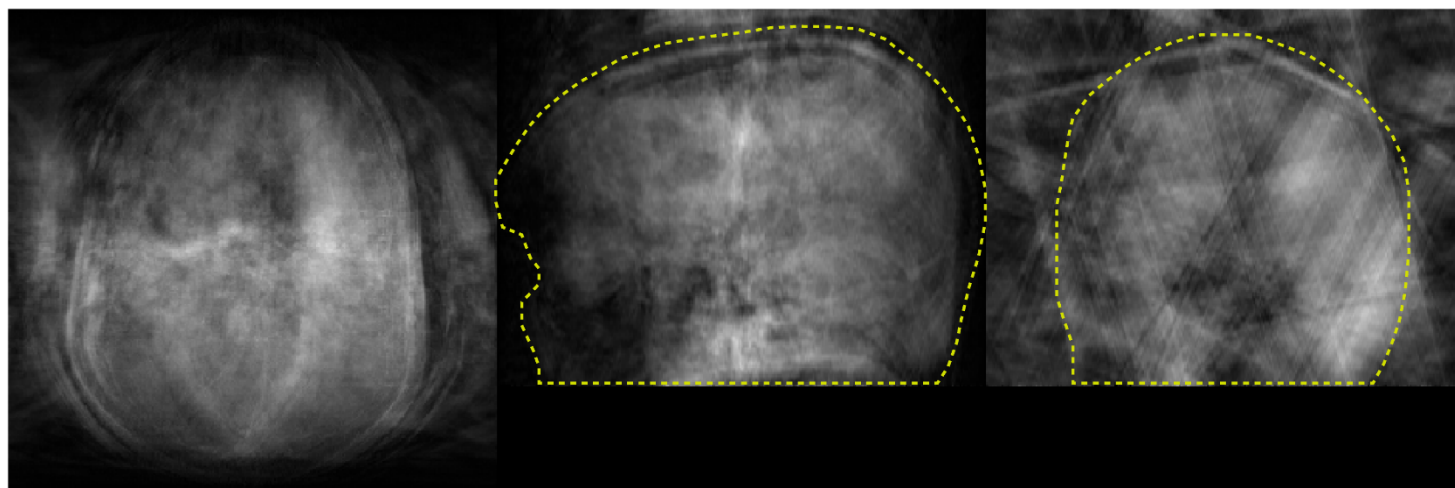
Limited coverage and resolution

Under-sampling reconstruction

- 5s temporal resolution, 30x undersampling
 -> 100 slices, $0.9 \times 0.9 \times 1.9 \text{ mm}^3$ in plane resolution



Cartesian **Golden-angle**
radial sampling at 30x



Zero-padded images

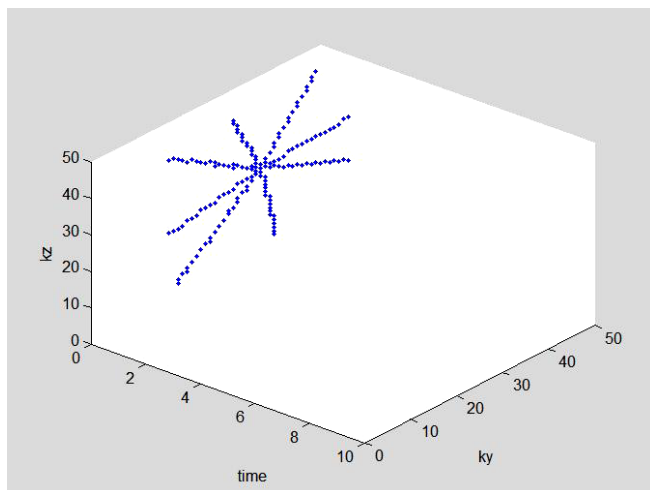


Under-sampling reconstruction

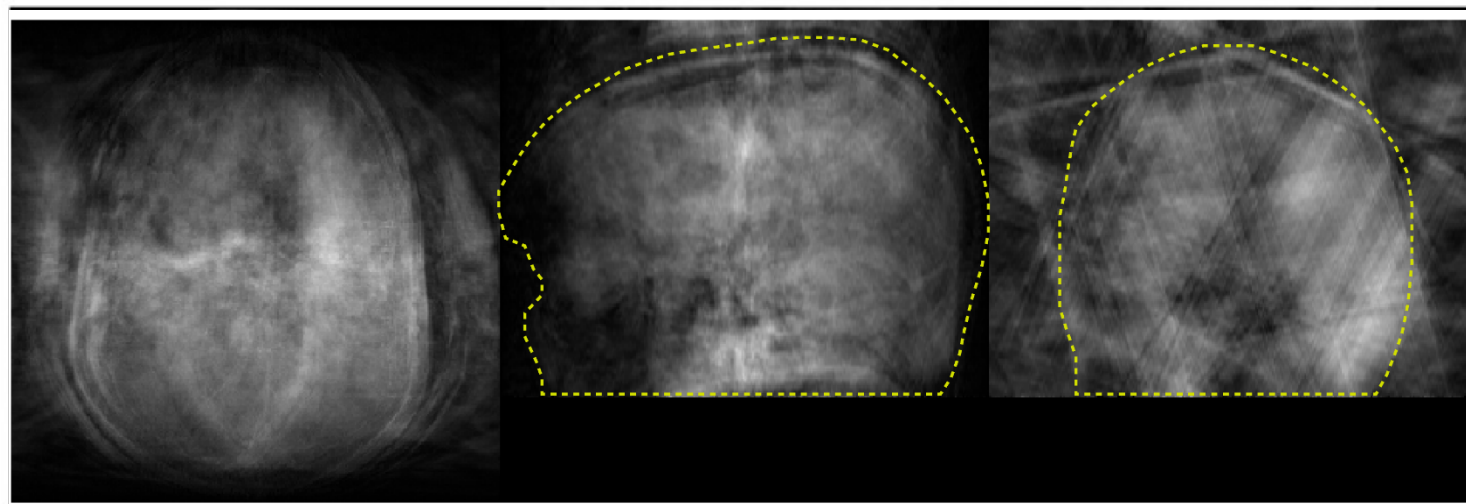
- Constrained reconstruction:

$$x = \underset{x}{\operatorname{argmin}} \|y - F_u Sx\|_2^2 + \lambda_1 \|Vx\|_1 + \lambda_2 \|TVx\|_1 + \lambda_3 \|x\|_1 \quad [1]$$

Spatial and temporal sparsifying transform

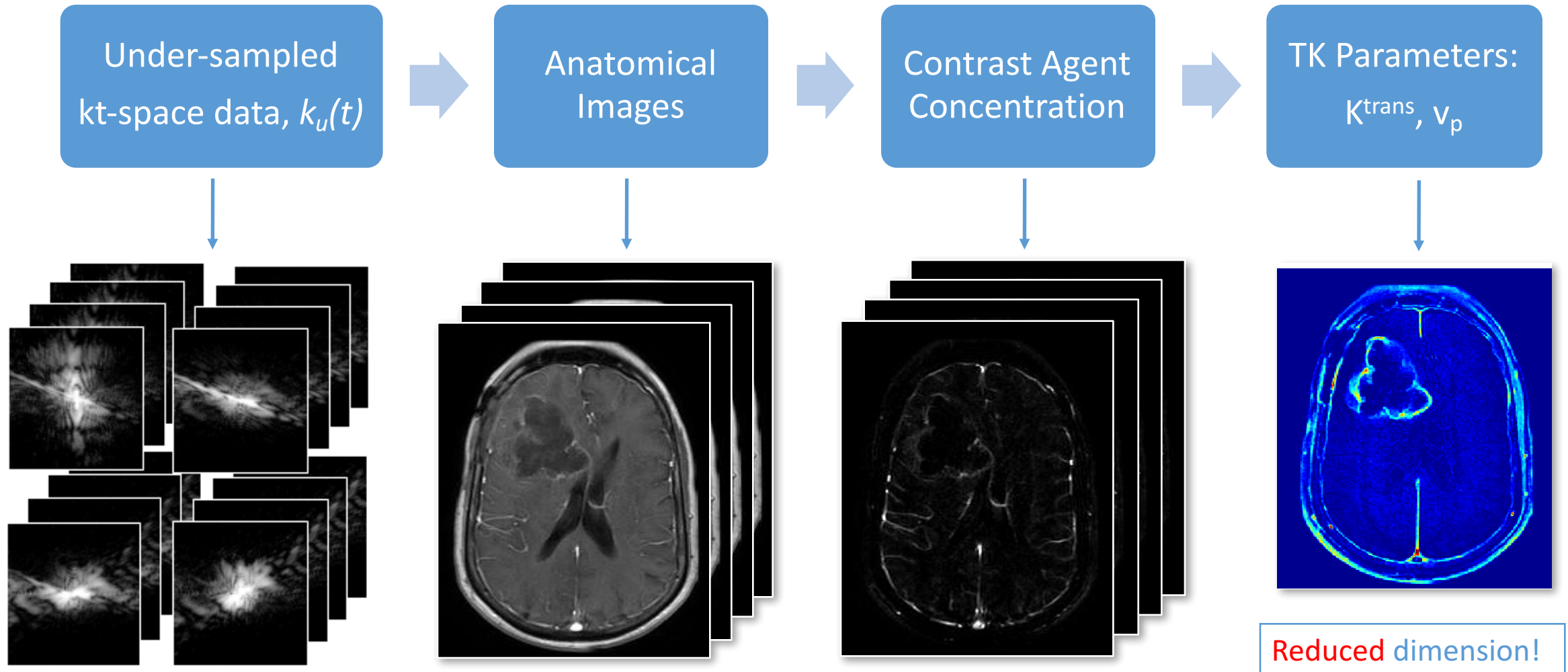


Cartesian **Golden-angle**
radial sampling at 30x

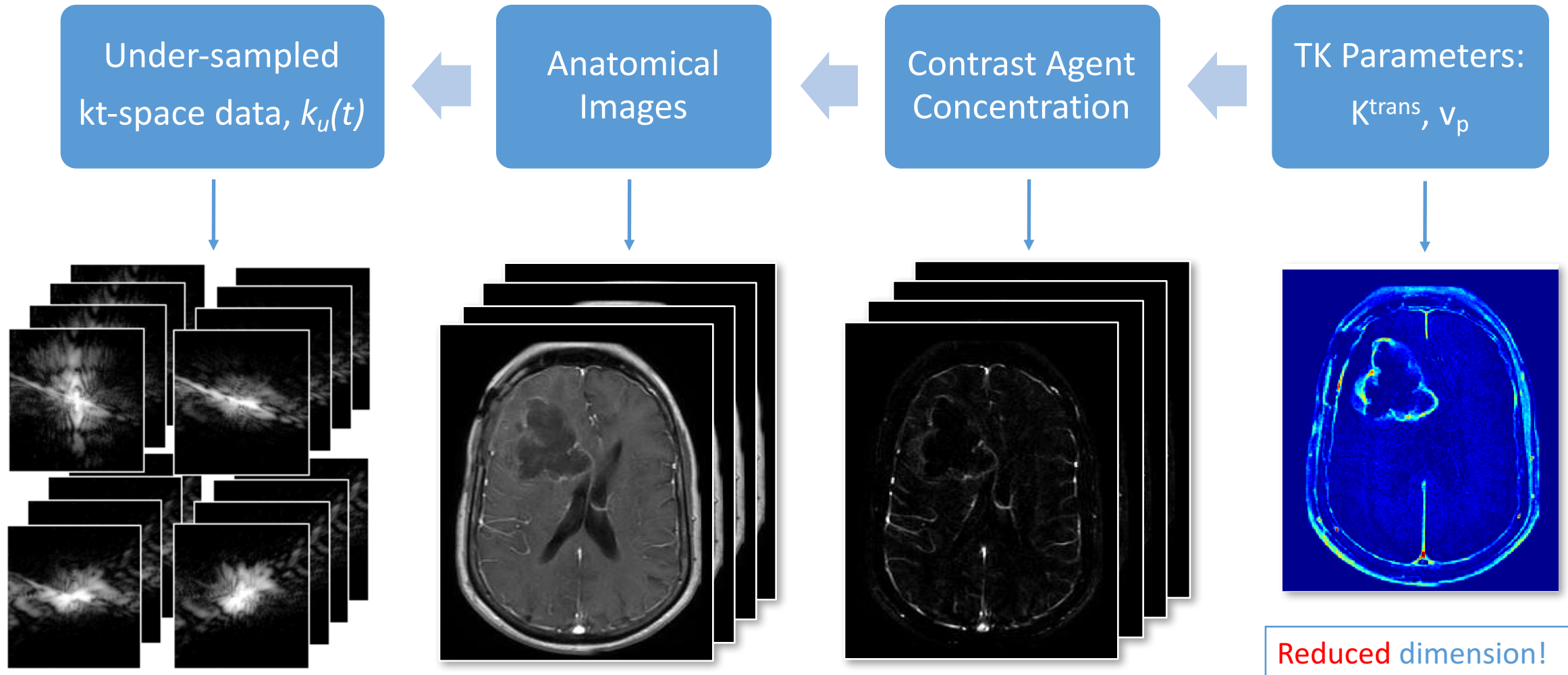


Reconstructed images
Zero-padded images
Whole-brain coverage

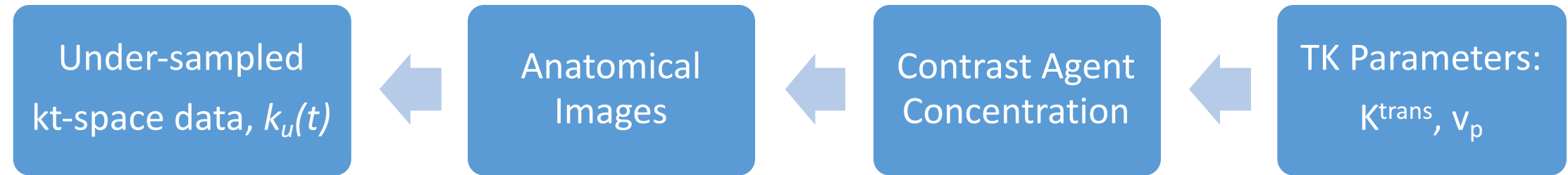
Indirect estimation of TK parameter maps



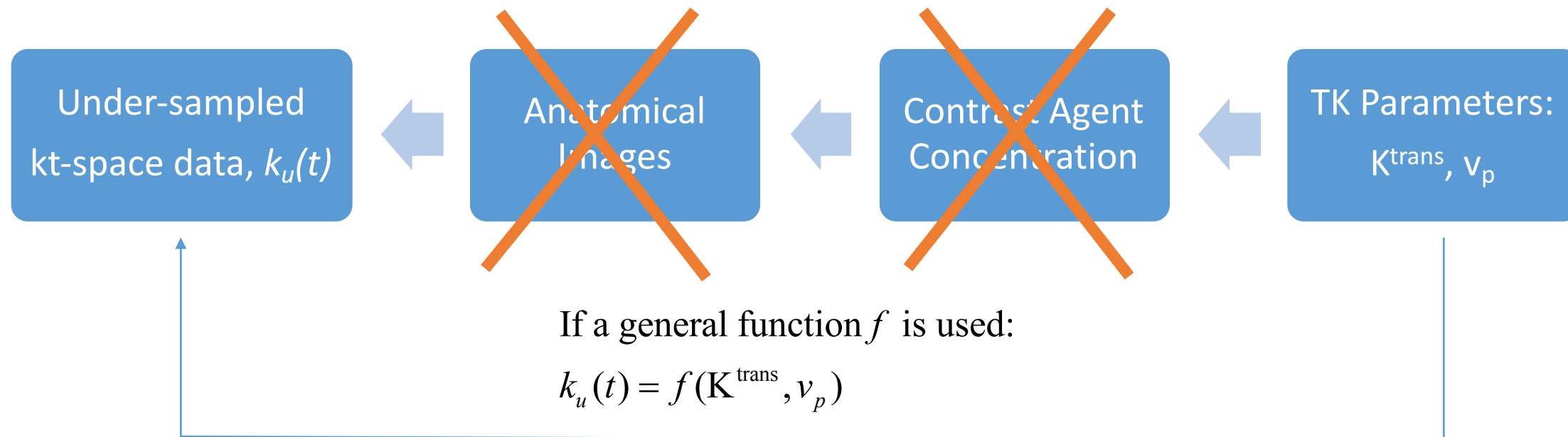
Forward modelling of TK parameter maps



Forward modelling of TK parameter maps



Model-based direct estimation



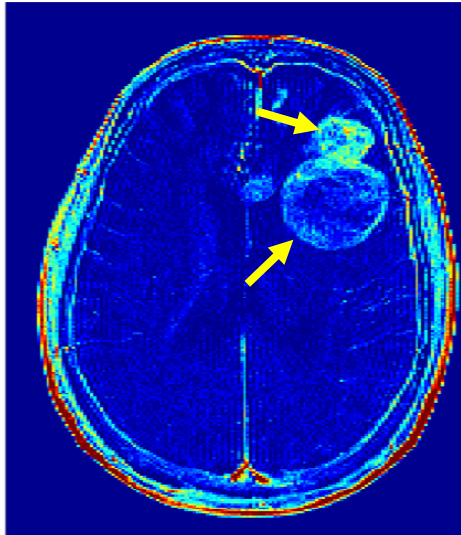
Can solve PK maps with an optimization problem:

$$(K^{trans}, v_p) = \underset{K^{trans}, v_p}{\operatorname{argmin}} \| k_u(t) - f(K^{trans}, v_p) \|_2^2$$

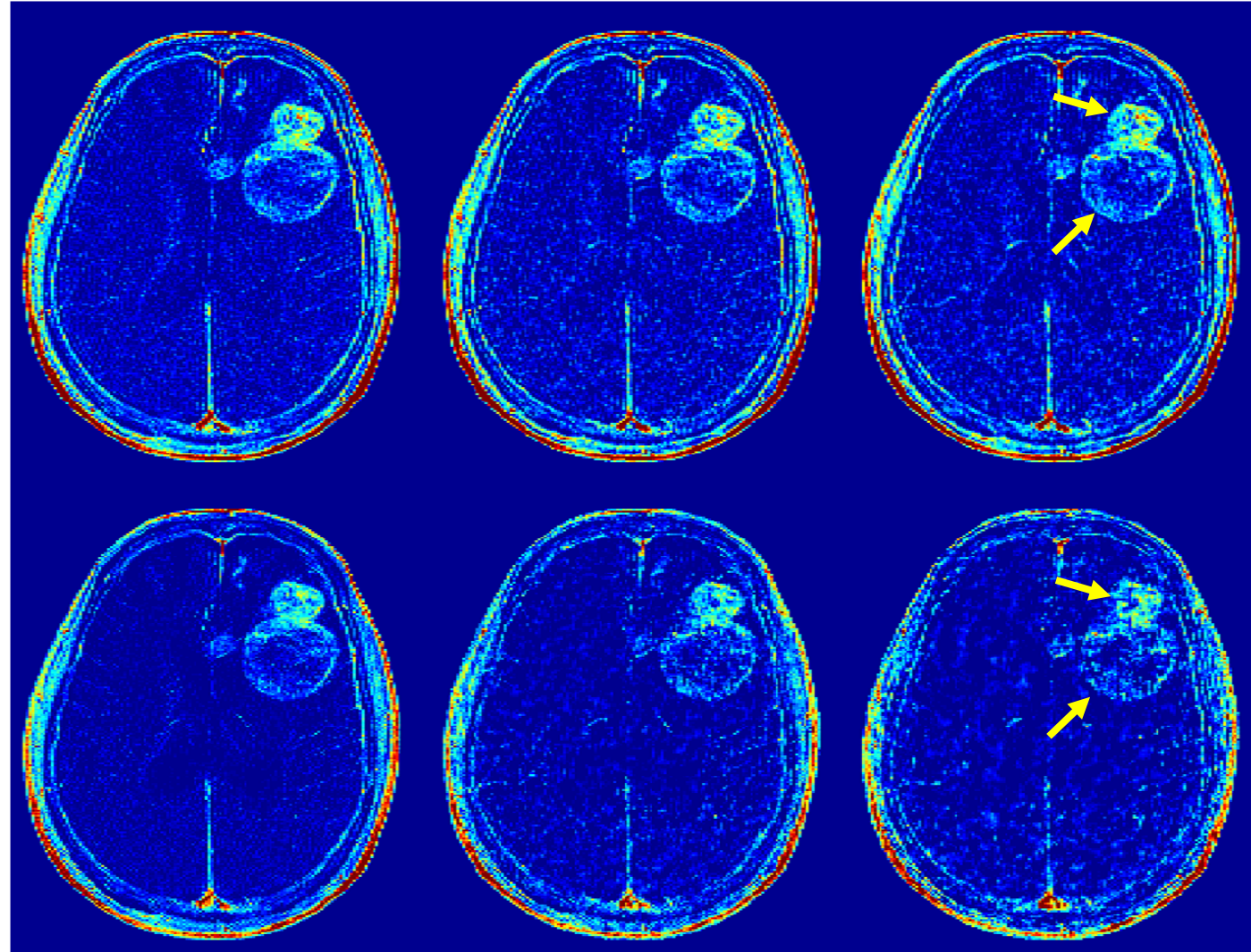
An efficient gradient-based L-BFGS method
is used to solve the optimization problem

Up to 100x in retrospective study

K^{trans} maps



Fully
sampled



Direct

Indirect

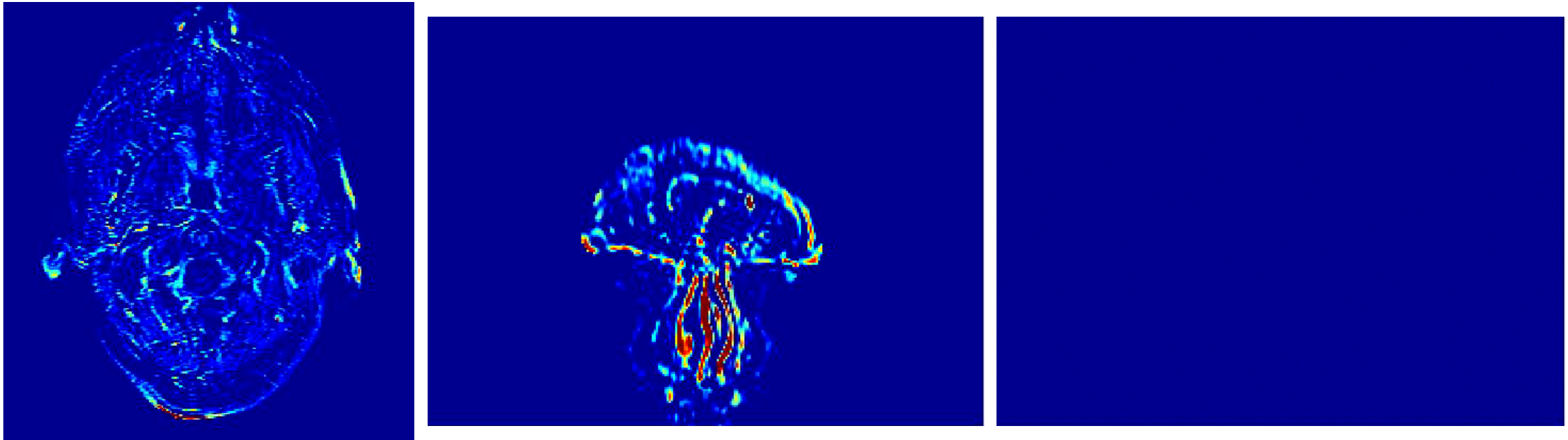
20x

60x

100x

Whole-brain TK maps by model-based direct reconstruction

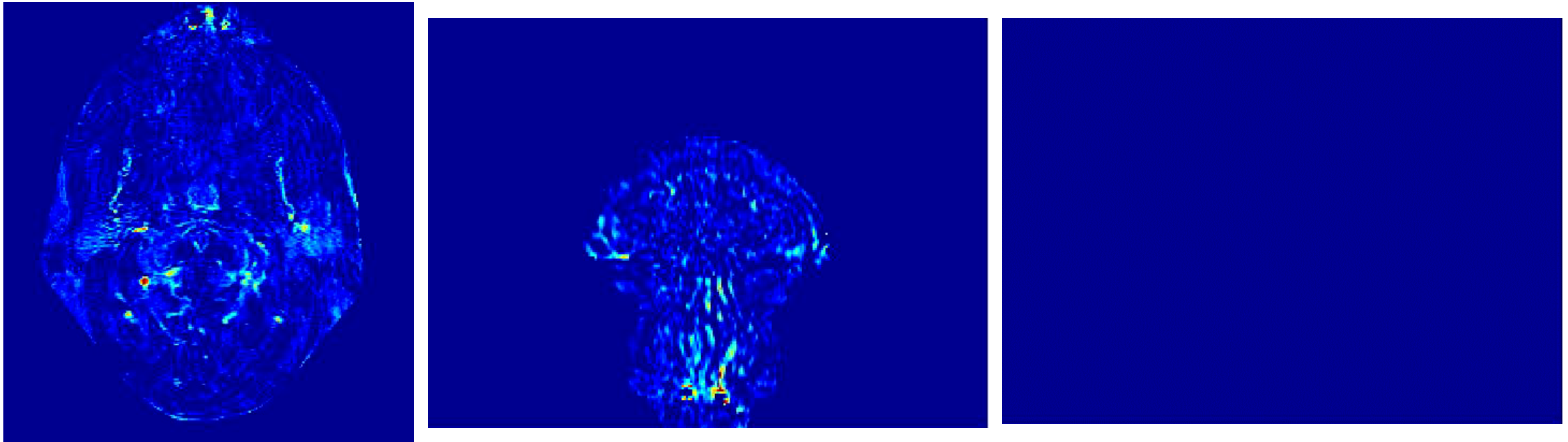
K^{trans} maps



Yi Guo, et al. Direct Estimation of Tracer-Kinetic Parameter Maps from Highly Under-sampled Brain DCE-MRI, *Magnetic Resonance in Medicine* (early view)

Whole-brain TK maps by model-based direct reconstruction

V_p maps



Yi Guo, et al. Direct Estimation of Tracer-Kinetic Parameter Maps from Highly Under-sampled Brain DCE-MRI, *Magnetic Resonance in Medicine* (early view)