#0234

A nonlinear model for DTI reconstruction with locally low-rank regularization

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Declaration of Financial Interests or Relationships

Speaker Name: Yuxin Hu

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

Company Name: GE Healthcare
Type of Relationship: Research Support

Diffusion-weighted imaging

Multi-shot:

- High resolution/reduced distortion

Multi-direction:

- Fiber direction

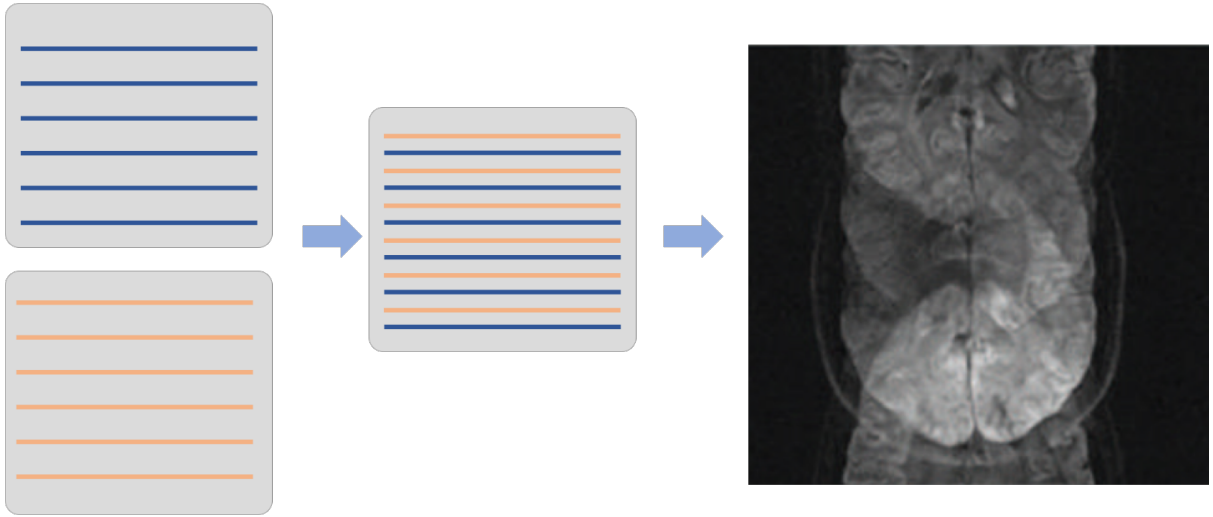
How to use the correlations between both different **shots** and different **directions** to help with reconstruction?

$$\min_{m,\theta} \sum_{d=1}^{ND} \sum_{s=1}^{NS} \frac{1}{2} \left\| E_{d,s} F S \left(m_d \cdot e^{j\theta_{d,s}} \right) - y_{d,s} \right\|_2^2 + \lambda_1 \sum_{l} \| R_l m \|_*$$

Diffusion-weighted imaging

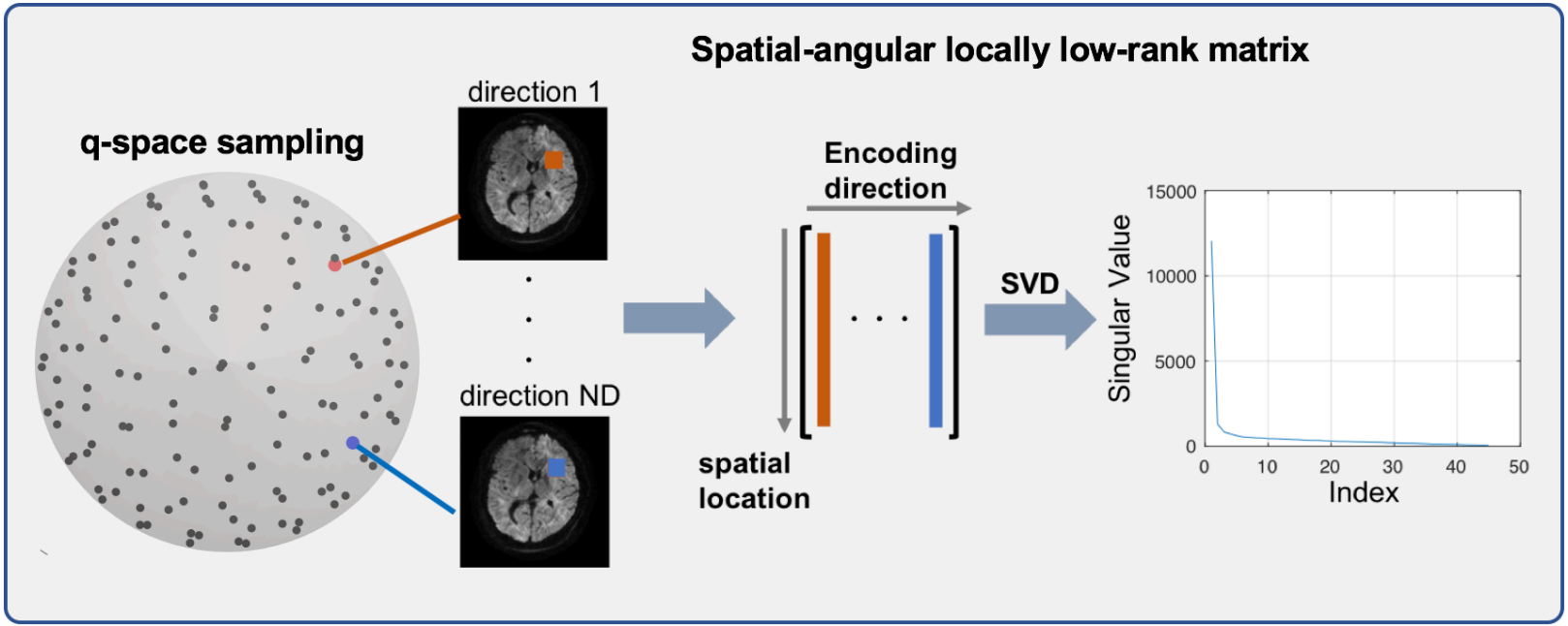
- Motion-induced phase variations:

$$\min_{m,\theta} \sum_{d=1}^{ND} \sum_{s=1}^{NS} \frac{1}{2} \left\| E_{d,s} F S \left(m_d \cdot e^{j\theta_{d,s}} \right) - y_{d,s} \right\|_2^2 + \lambda_1 \sum_{l} \| R_l m \|_*$$



LLR in multi-direction DWI

- Using locally-low rank to implicitly utilize relationships between different diffusion encoding directions

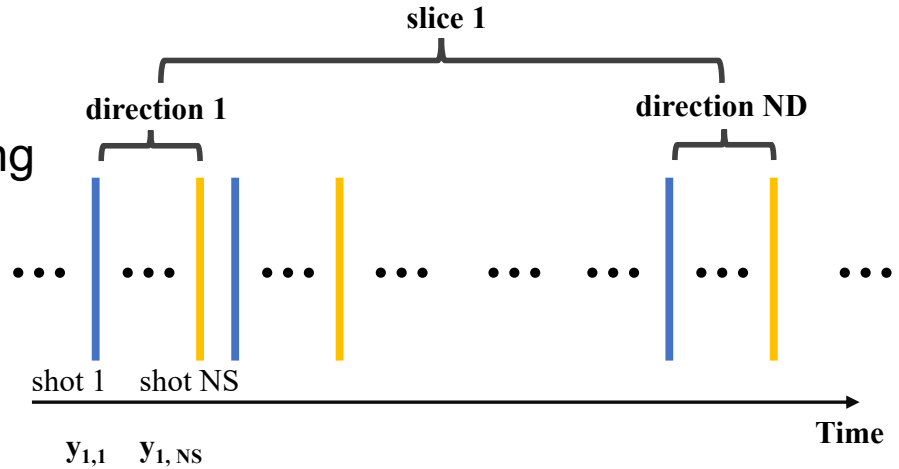


Non-linear model

- Data consistency term (multi-dir, multi-shot data) + LLR

$$\min_{m,\theta} \sum_{d=1}^{ND} \sum_{s=1}^{NS} \frac{1}{2} \left\| E_{d,s} F S \left(m_d \cdot e^{j\theta_{d,s}} \right) - y_{d,s} \right\|_2^2 + \lambda_1 \sum_{l \in \Omega} \| R_l m \|_*$$

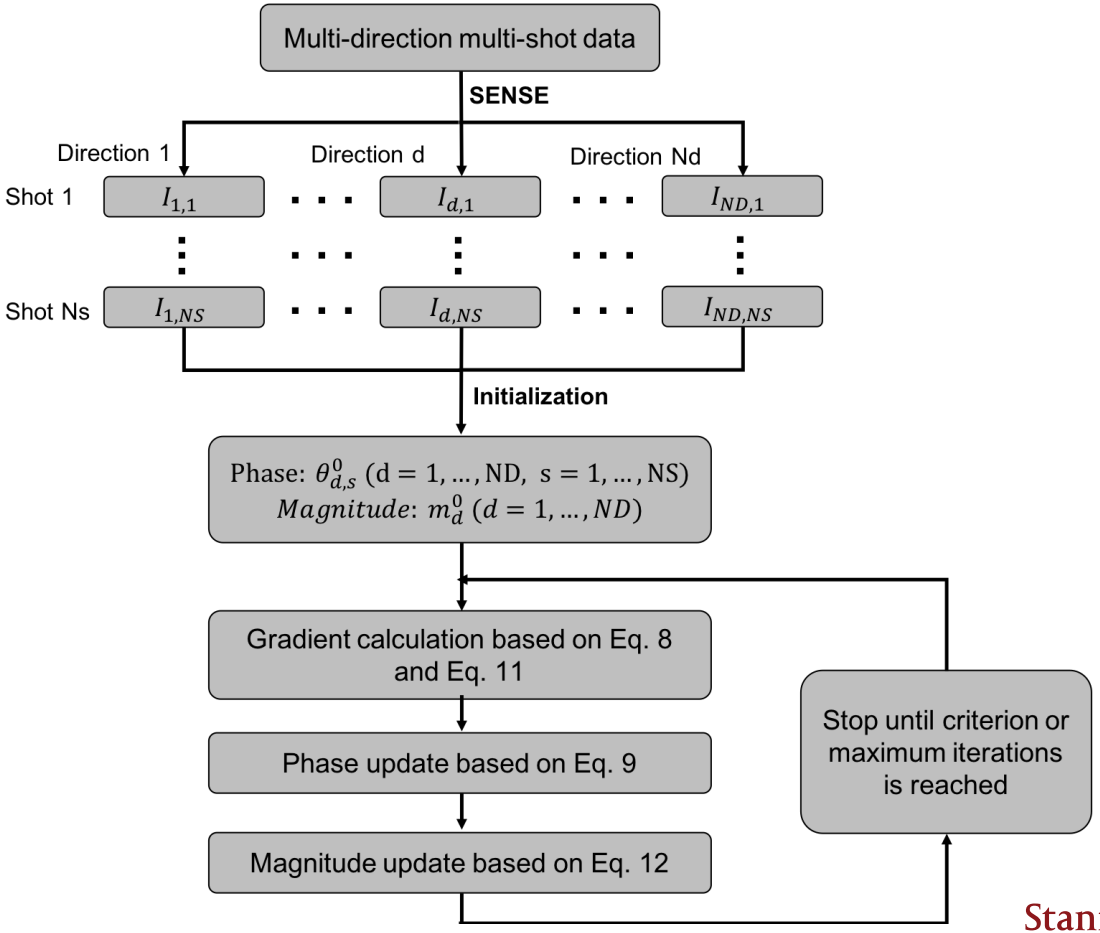
E: sampling pattern
F: Fourier transform
S: sensitivity encoding



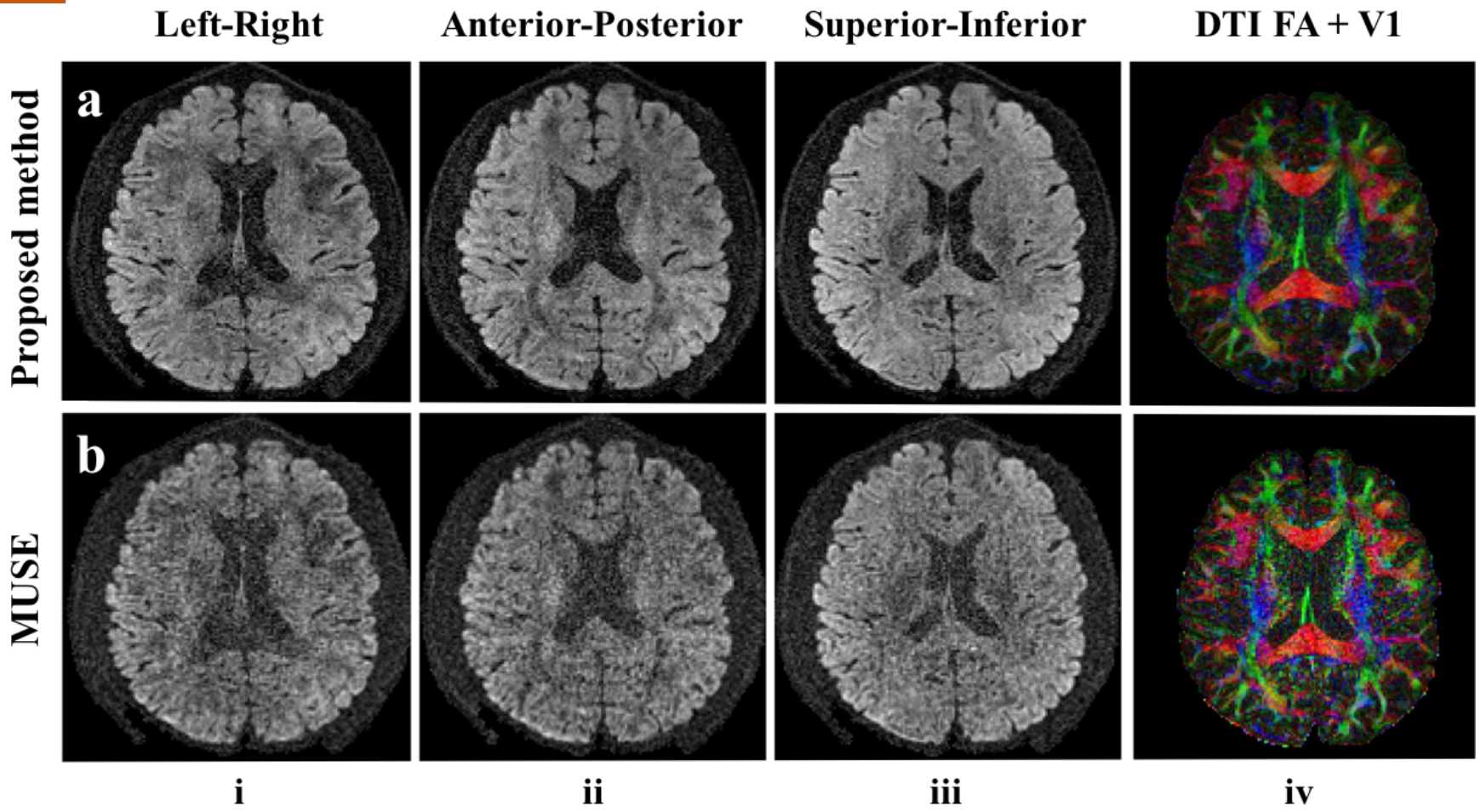
Acquired data $\mathbf{y}_{1,1}$ $\mathbf{y}_{1,NS}$

Phase & Mag to be reconstructed $\boldsymbol{\theta}_{1,1}, \boldsymbol{\theta}_{1,NS}, \boldsymbol{m}_1$

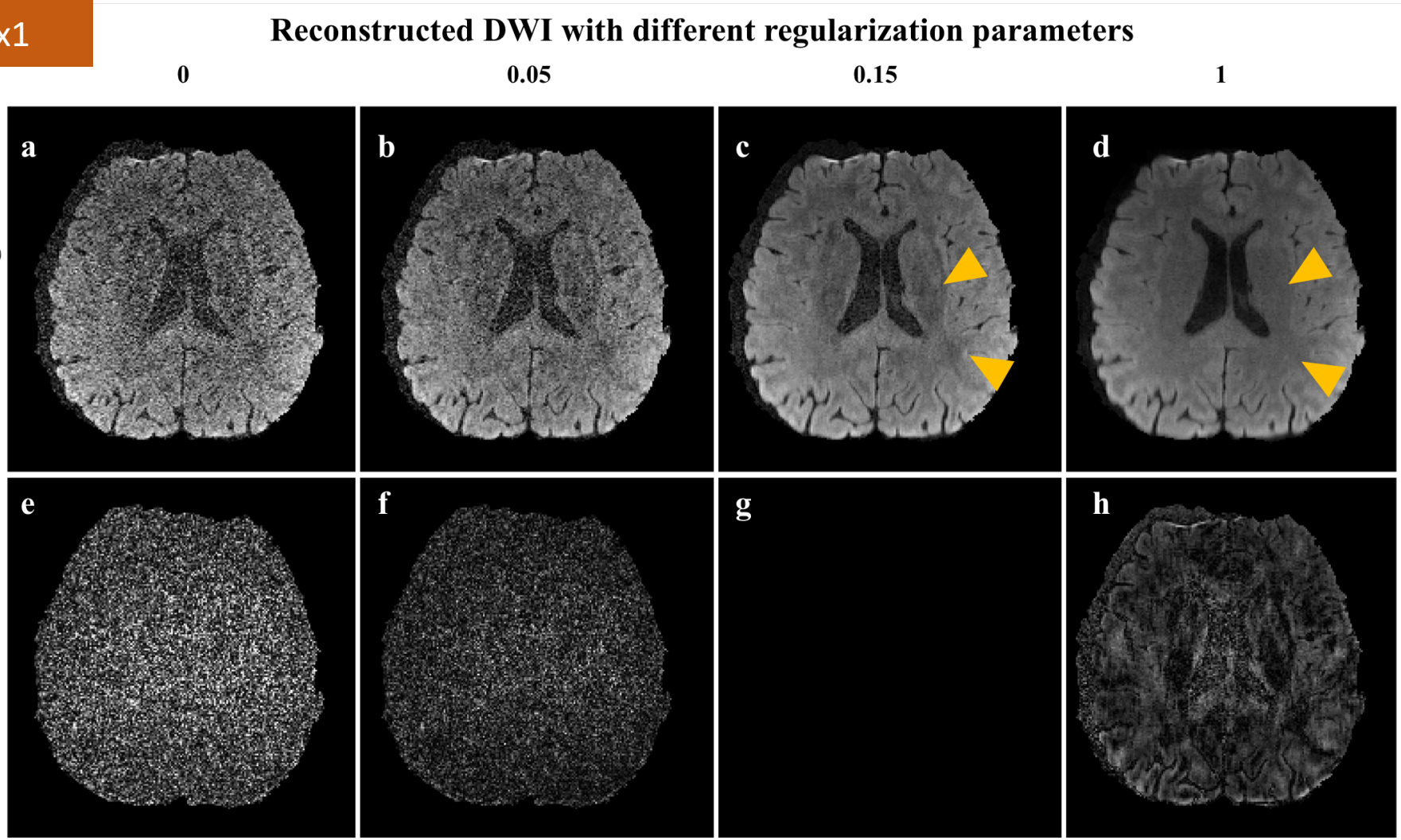
SENSE initialized joint reconstruction of multi-direction DWI with simultaneous magnitude and phase update



Parameters	Ex0 (to validate the method)	Ex1 (parameter selection)	Ex2 4-shot vs single-shot (R = 3)		Ex3 (different resolutions)	Ex4 (more directions)	Ex5 (high b-value)
TR/TE	2515/59.3	3375/49.7	2278/51.4	2478/63.5	2627/52.8, 2759/54.4, 2993/56.7	2853/53.1	2908/59.2
scan time	05:14	08:09	22:58	24:58	13:21, 14:01, 15:13	28:46	14:47
in-plane resolution/mm	1.2	0.9	1		0.9, 0.8, 0.7	0.9	1
slice thickness/mm	1.2	0.9	1		0.9, 0.8, 0.7	0.9	1
FOV/cm	20	20	18.4		20	20	20
#slices	12	14	10		11	12	10
partial Fourier factor	0.86	0.61	0.67	0.75	0.64, 0.63, 0.61	0.64	0.66
#directions	30	30	150		75	150	75
nex	1	1	1	4	1	1	1
b-value	1000	1000	1000		1000	1000	2000
#subjects	1	1	1		1	2	2

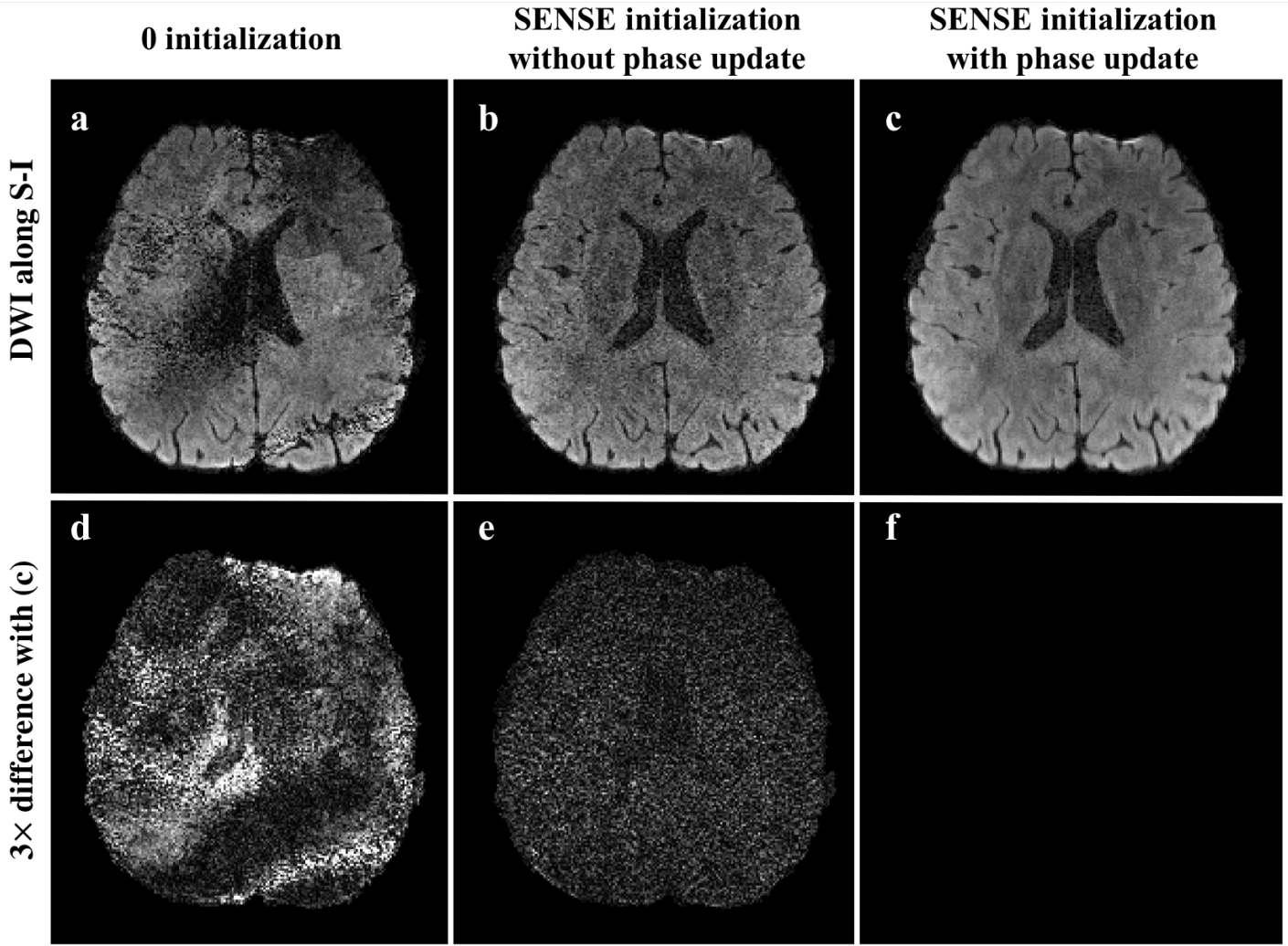

Left-Right
Anterior-Posterior
Superior-Inferior
DTI FA + V1
Proposed method
MUSE
a
b
i
ii
iii
iv

Ex1


Reconstructed DWI with different regularization parameters
0
0.05
0.15
1
DWI along S-I
3× difference with (c)
a
b
c
d
e
f
g
h

Ex1

#0234


0 initialization
SENSE initialization without phase update
SENSE initialization with phase update
DWI along S-I
3× difference with (c)
a
b
c
d
e
f

Reconstruction parameter

Parameters	Values
#iterations	100
Initialization of phase	hanning window (width = ½ matrix size)
Step size for phase	0.9
Step size for magnitude	0.9
Regularization parameter for LLR	0.12 ~ 0.18
Block size	8
Phase update	Y

Ex2

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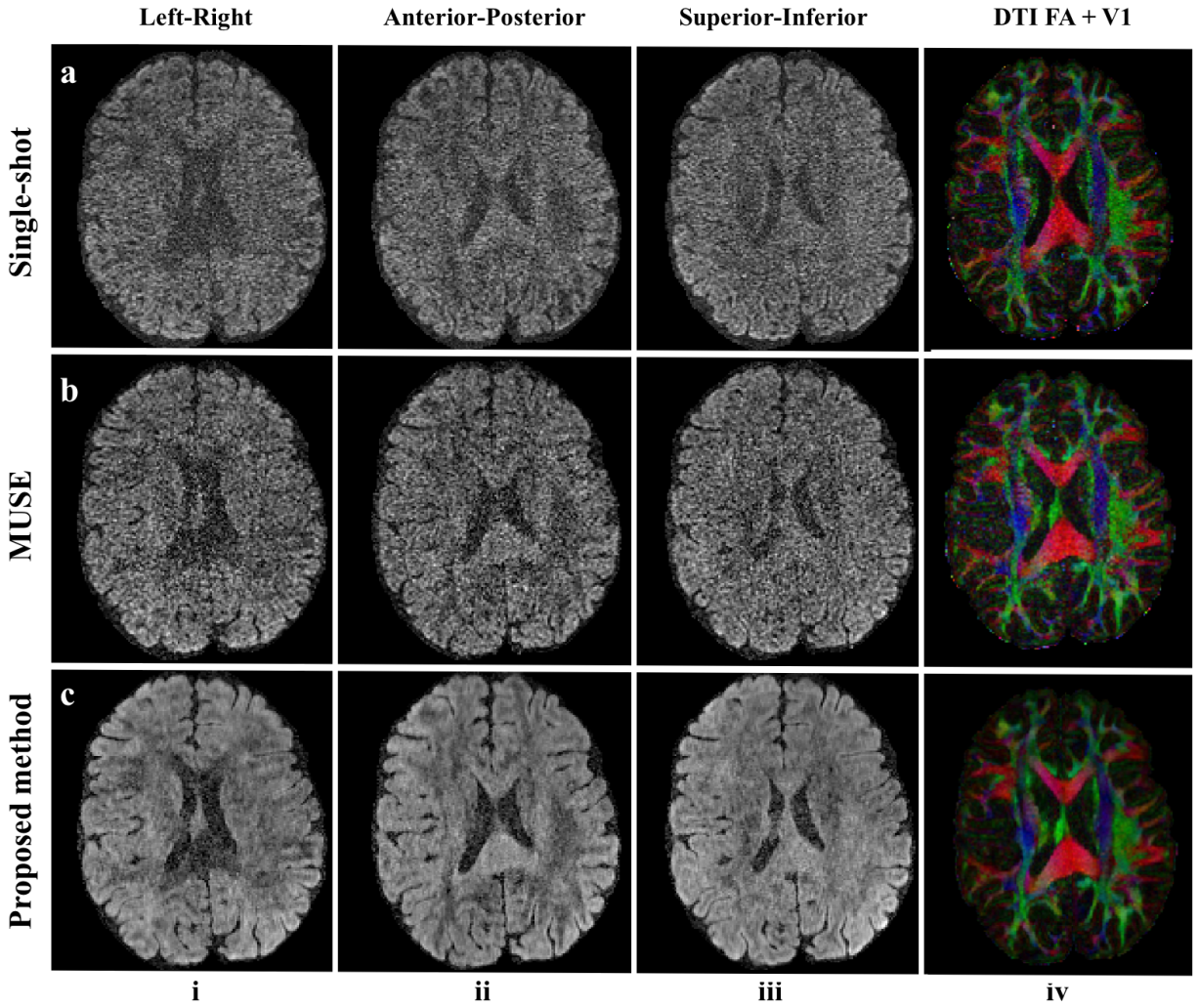
Left-Right
Anterior-Posterior
Superior-Inferior
DTI FA + V1
Single-shot
MUSE
Proposed method
a
b
c
i
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iii
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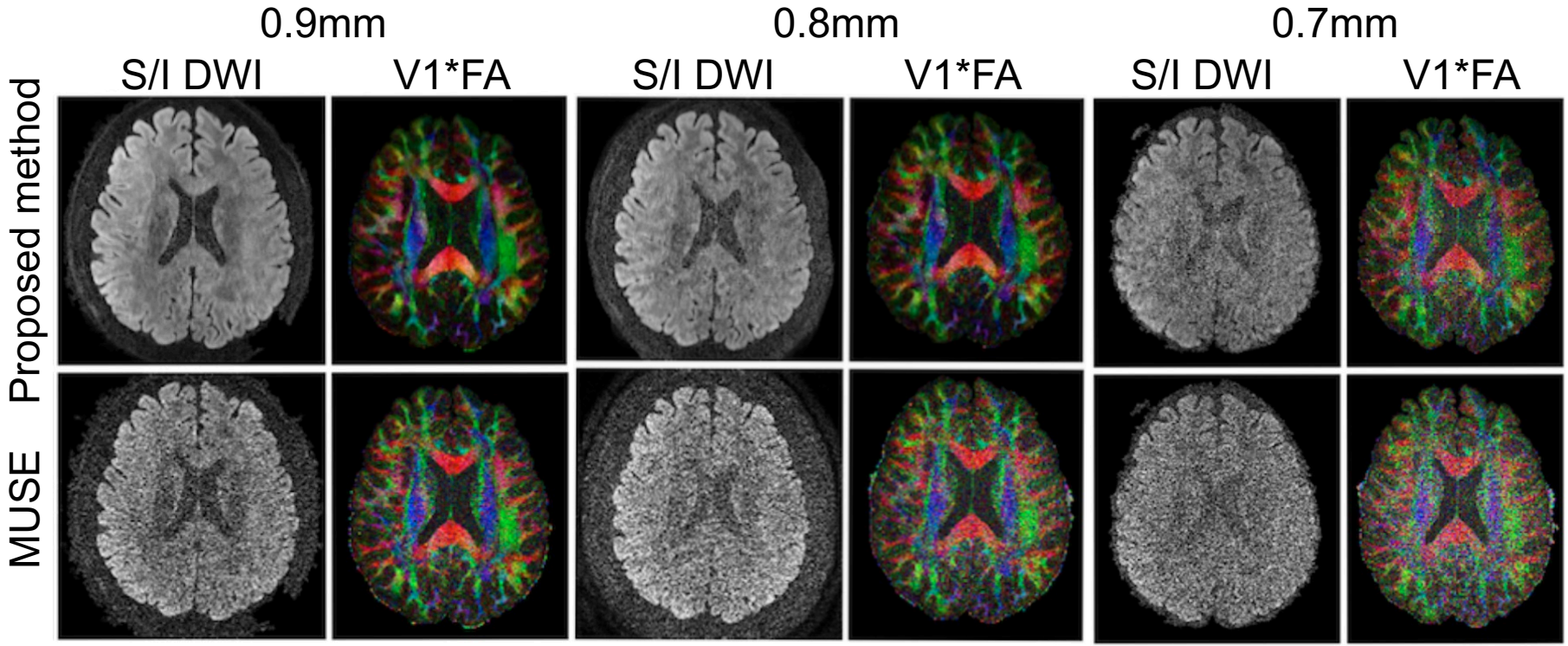
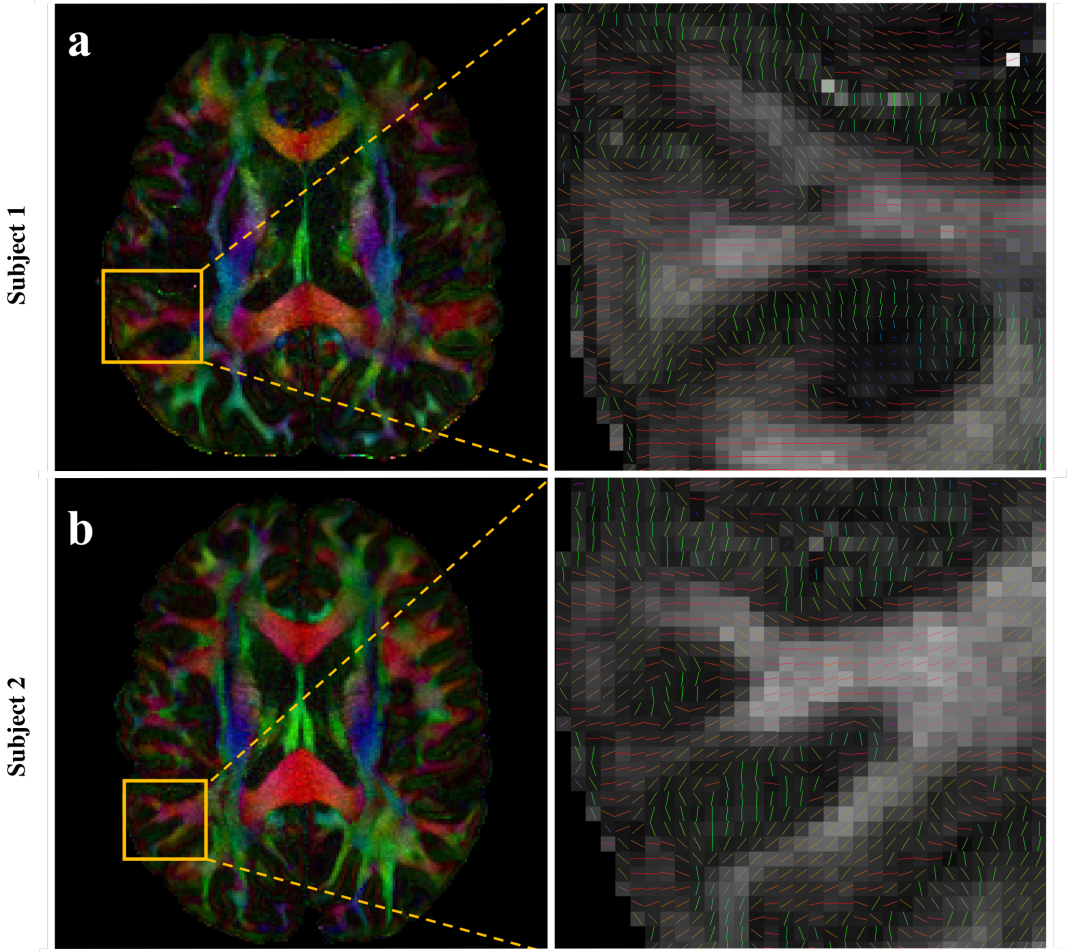
Results: proposed method vs MUSE



- *Ex3: 75 directions, b = 1000 s/mm^2, 13-15min Scan*



- *Ex4: 0.9 isotropic mm, 150 directions, b = 1000 s/mm^2, 28min Scan*

Ex5: b2000

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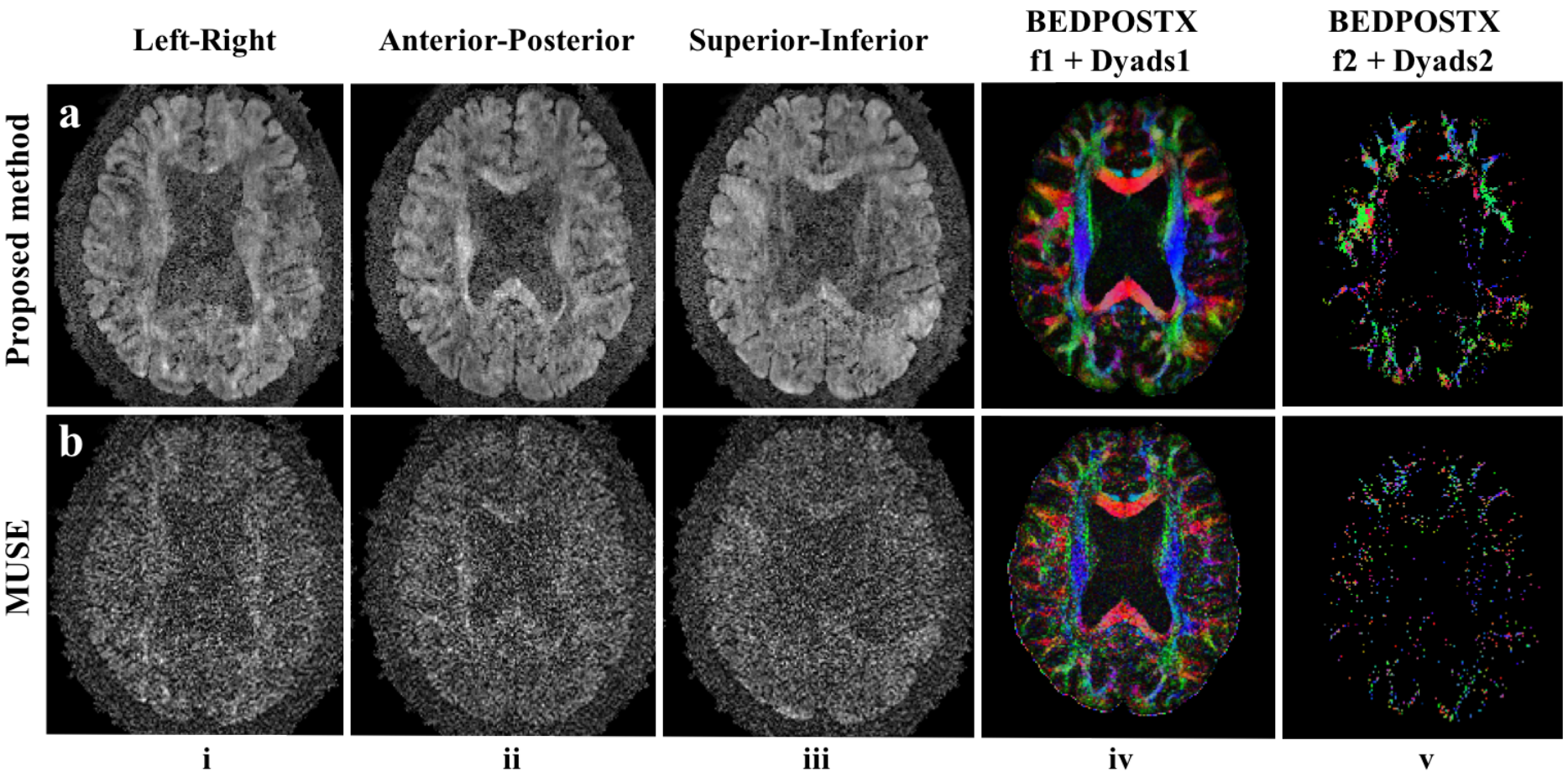

Summary

Two contributions for multi-direction multi-shot DWI reconstruction:

- Non-convex model with simultaneous phase and magnitude updates
- LLR to utilize angular correlation