

「EPIシーケンスにおける歪み対策」
—歪みの原理と各社装置のパラメータを熟知する—

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信州大学医学部附属病院
長野県MR研究会Ⅱ

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GE社製 MRI装置

$$\text{Distortion (mm)} = d\text{FB (Hz)} \times \text{FOV (mm)} \times \text{ESP (msec)} \times \frac{r\text{FOV}}{Rf \times n\text{Shot}}$$

DWIはSingleのみ

- ・ ESPの確認は出来ない(optionを一定にし、TEで判断)
- ・ 設定条件の組み立て(TEの設定、k-space trajectoryの再確認、その他)

ESPの表示が無いいためTEで判断する

Dual Spine echo : 渦電流の影響軽減 (TE延長)
Optimized TE : TE短縮 (枚数減少)

ESPは変わらないため位相方向の歪みに変化なし

Ramp Sampling OnによりESP短縮し歪み低減
Ramp Sampling Offの時は、最短TEになるBW
で最短ESPとなる

SE-EPI位相方向の歪みに依存しない
 (このOptionを開かずに最短TEになるよう設定すると最短ESP)

The screenshot displays the MRI scanner control software interface, divided into several sections:

- Scan Timing:** A table with columns for parameter names, Min., and Max.

Parameter	Value	Min.	Max.
# of Shots	1		
TE	Minimum	95.9	95.9
TE2		20.0	2000.0
TR	5000.0	1000.0	17000.0
Inv. Time		50	4000
T12		50	4000
Flip Angle		1	180
Echo Train Length			
Bandwidth	200.00	62.5	250.0
Bandwidth2		0.0	250.0
- Additional Parameters:** A grid of icons for various options. The **DWI Screen** icon, which shows a brain with yellow circles, is circled in red. Other options include Graphic Rx, Image Enhance, and User CVs Screen.
- Acquisition Timing:** A section for setting acquisition parameters.

Freq	128	Freq DIR	A/P
Phase	128	Flow Comp Direction	
NEX	1.00	Shim	Auto
Phase FOV	1.00	Phase Correct	<input checked="" type="checkbox"/>
Locs Before Pause		Contrast	<input type="checkbox"/>
		Amf	
		Agent	
- Scanning Range:** A section for defining the scan range.

Parameter	Value	Min.	Max.	S / I	L/R Center	P/A Center
FOV	35.0	24	60	Start	14.7	0.0
Slice Thickness	5.0			End	14.7	
Spacing	2.0			# of Slices	1	
				Actual End	14.7	

At the bottom of the interface, there are summary statistics and control buttons:

- Rx Scan Time:** 0:20
- Max # of Slices:** 32
- Rel. SNR(%):** 100 (Drive FPS: <1)
- Est. SAR:** 0.0
- Peak SAR:** 0.0
- dB/dt:** First Level
- SAR:** First Level
- Buttons: **Save Series**, **Reset Values**
- Summary: # of Acqs.: 1, Total # Slices: 1

Diffusion Option

b-Value

Diffusion Direction

of Diffusion Directions

of T2 Images

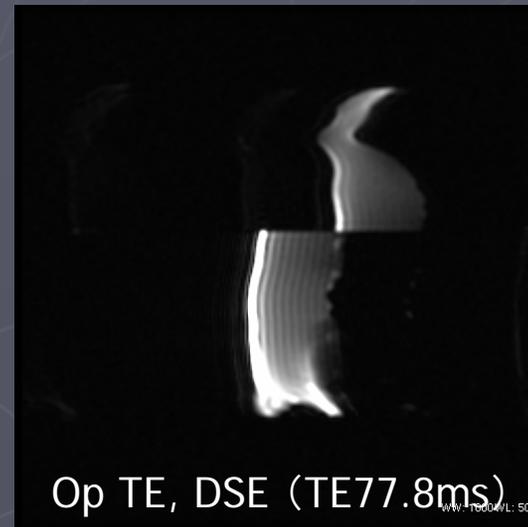
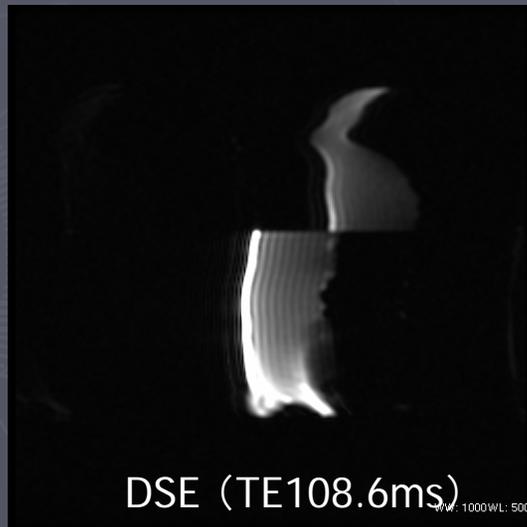
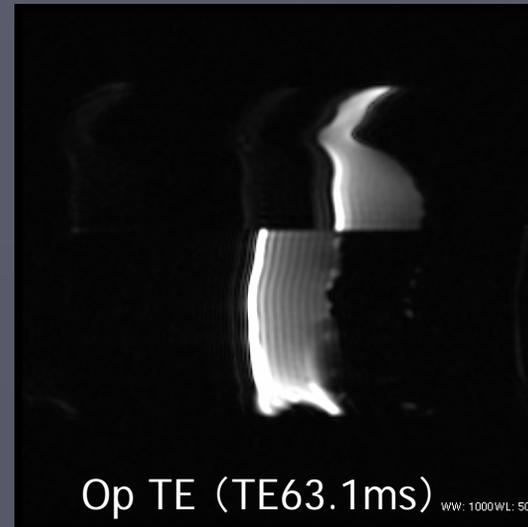
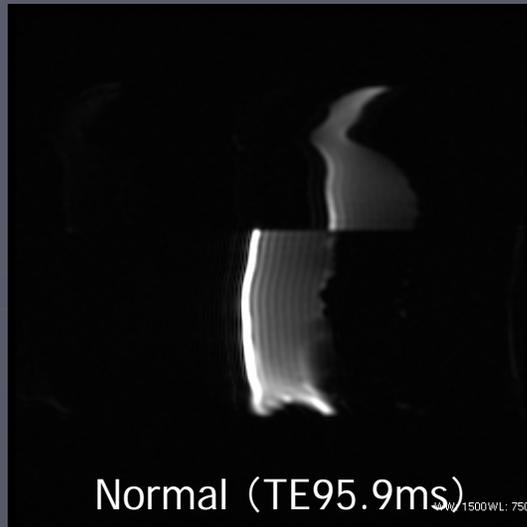
Recon All Images **Optimize TE** Dual Spin Echo

Diffusion Tensor Processing Outputs

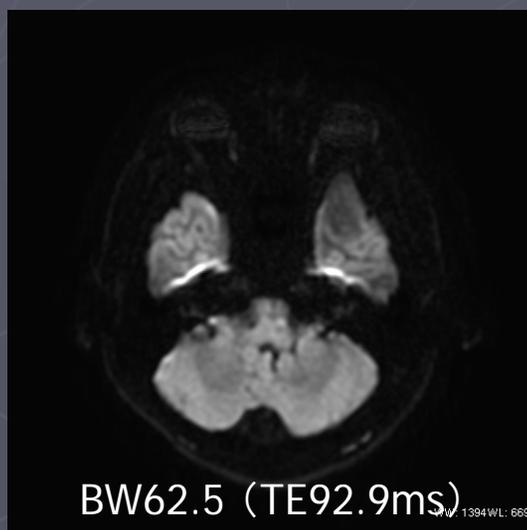
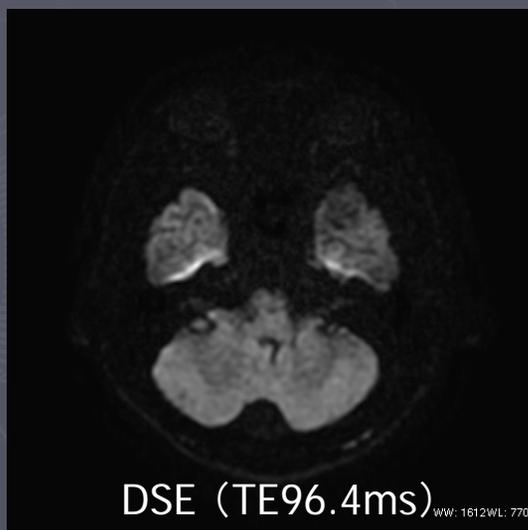
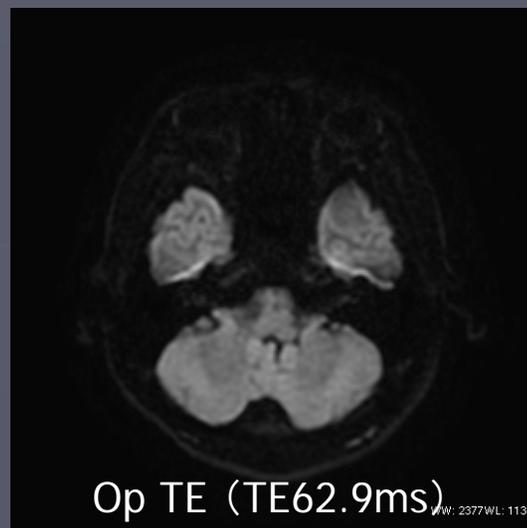
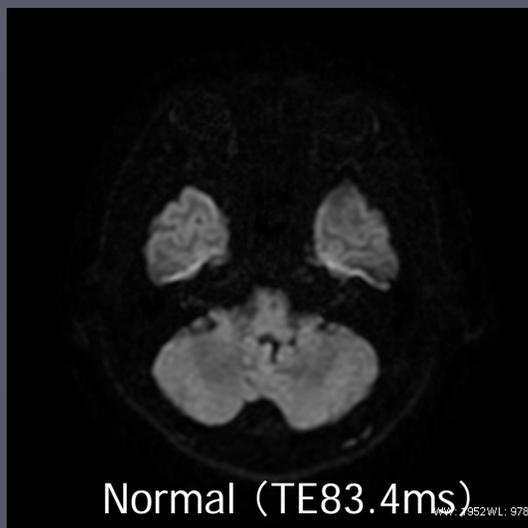
ADC Fractional Aniso. Combined

ESP変わらない

DWI Screen (DWI Option)



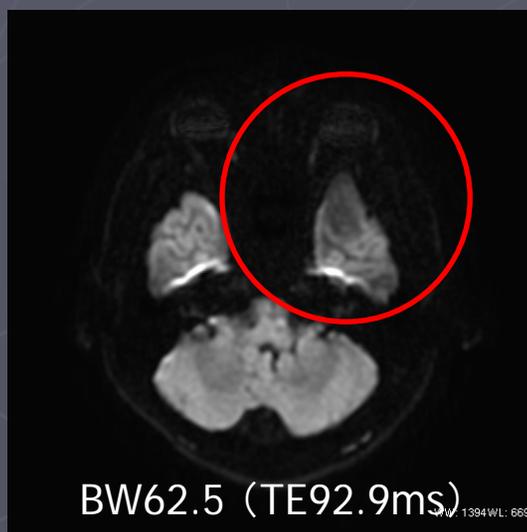
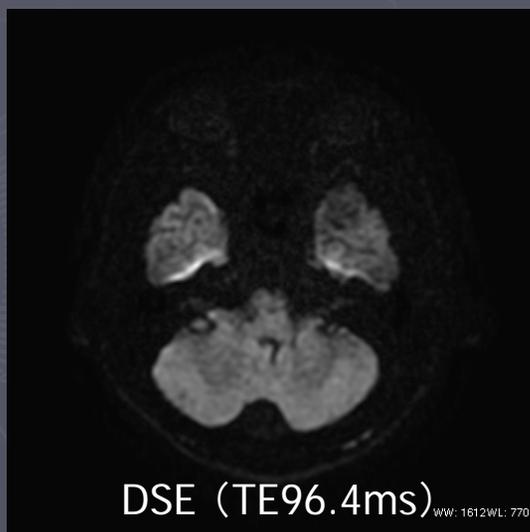
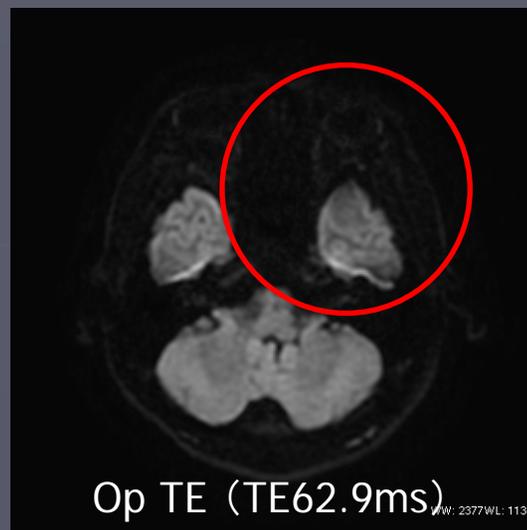
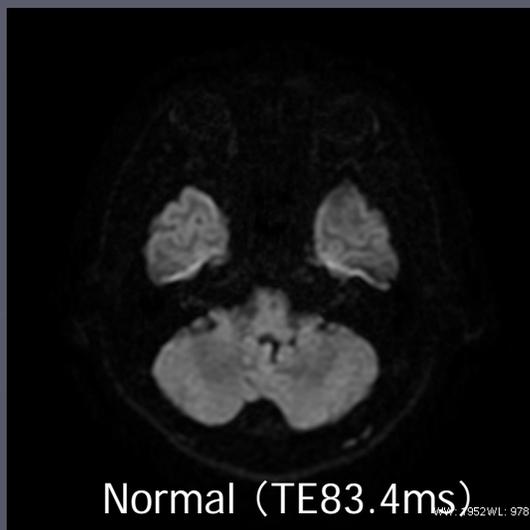
ESP 688 μ s



ESP 588 μ s

健康ボランティア倫理委員会承認済

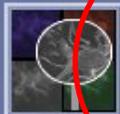
ESP 1200 μ s



Scan Timing

	Min.	Max.
# of Shots		
TE	95.9	95.9
TE2	20.0	2000.0
TR	1000.0	17000.0
Inv. Time	50	4000
T12	50	4000
Flip Angle	1	180
Echo Train Length		
Bandwidth	62.5	250.0
Bandwidth2	0.0	250.0

Additional Parameters

			
Graphic Rx	OFF	Image Enhance	User CVs Screen
			
DWI Screen			

Acquisition Timing

Freq	128	Freq DIR	A/P
Phase	128	Flow Comp Direction	
NEX	1.00	Shim	Auto
Phase FOV	1.00	<input checked="" type="checkbox"/> Phase Correct	
Locs Before Pause		<input type="checkbox"/> Contrast	
		Amf	ml
		Agent	

Scanning Range

	Min.	Max.	S / I	L/R Center	P/A Center
FOV	24	60	Start	14.7	0.0
Slice Thickness			End	14.7	
Spacing			# of Slices	1	
			Actual End	14.7	

Rx Scan Time: 0:20

Max # of Slices: 32

Rel. SNR(%): 100
 (Drive FPS: <1)

Est. SAR: 0.0
 Peak SAR: 0.0

dB/dt: First Level
 SAR: First Level

Save Series

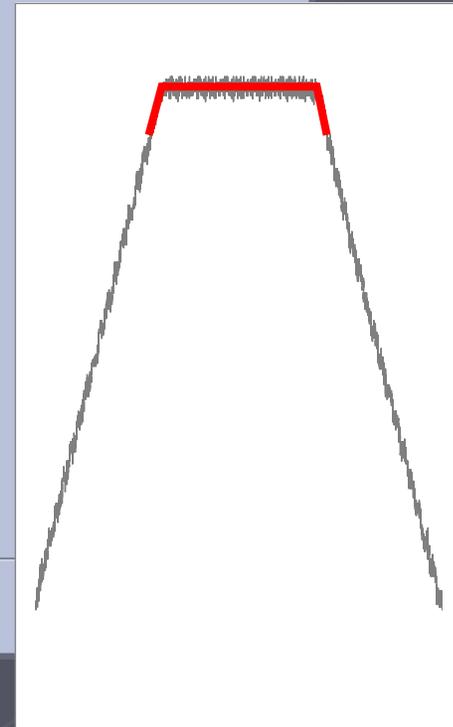
of Acqs.: 1

Total # Slices: 1

Reset Values

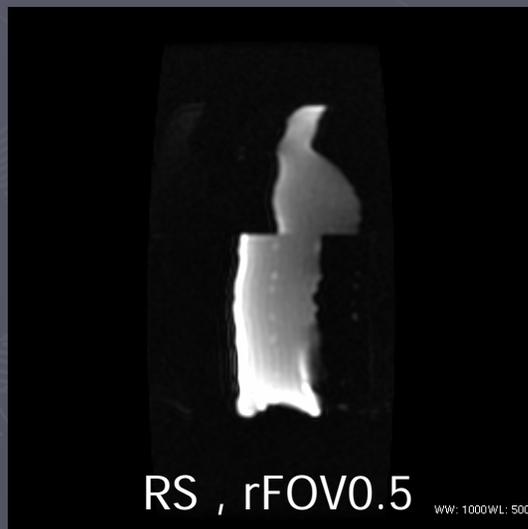
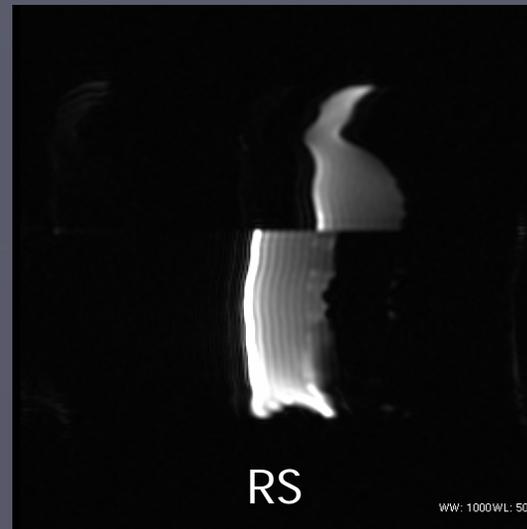
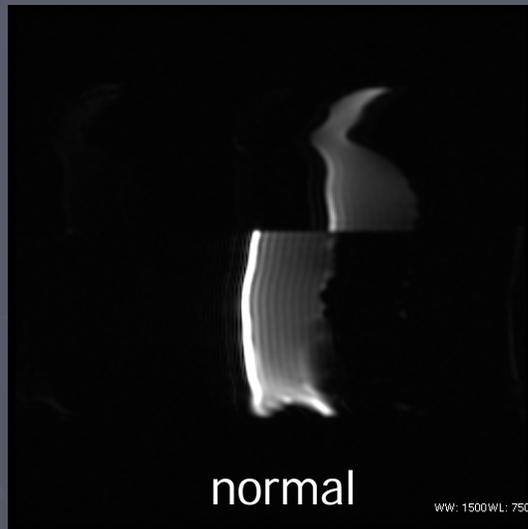
User Control Variables

			Minimum	Maximum
CV 0	Ramp Sampling (1=on, 0=off)	<input type="text" value="1.00"/>	0	1
CV 6	FLAIR Inversion (1=on, 0=off)	<input type="text" value="0.00"/>	0	1

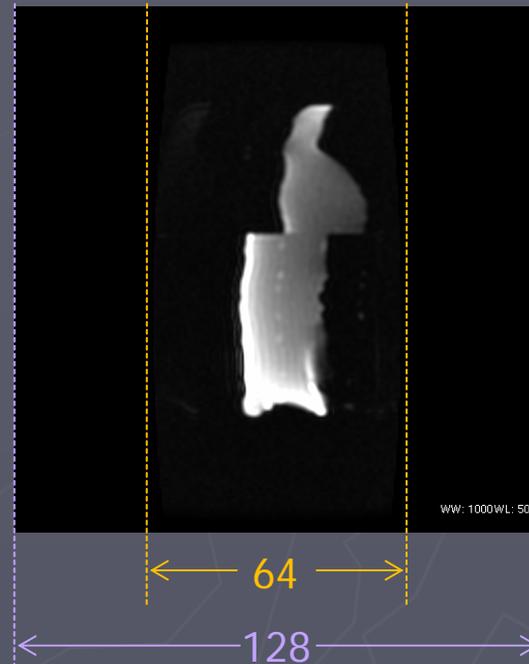


Ramp Sampling使用にて、自動で最短ESPとなる。(BW±250kHz固定)

User CV Screen (Ramp Sampling)



EPIのRectangular FOV(Phase FOV)の分解能



$$\text{True Phase Matrix} = \text{Phase} / \text{Phase FOV}$$

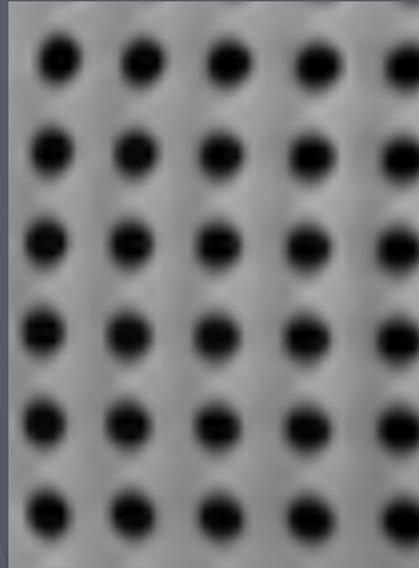
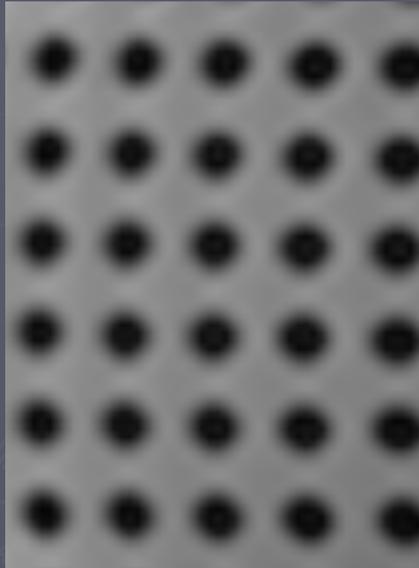
Phaseを128固定

Phase FOV 1.0 = 128 Matrix

Phase FOV 0.8 = 160 Matrix

Phase FOV 0.5 = 256 Matrix

EPIのRectangular FOV (Phase FOV)の分解能



Freq	128	>
Phase	128	>
NEX	1.00	>
Phase FOV	1.00	>

Freq	128	>
Phase	128	>
NEX	1.00	>
Phase FOV	0.50	>

=

Freq	128	>
Phase	256	>
NEX	1.00	>
Phase FOV	1.00	>

GE社製MR装置のまとめ

DWI Optionの「Optimize TE」、「Dual Spine Echo」はEPIモジュール前のOptionであり、ESPに変化なし。

撮像領域(FOV)、Frequency matrix 決定後、Phase FOV及びASSETにより歪み低減が行える際は設定し、Ramp Samplingを選択する。
Off Centerなどで、Ghostが目立ちRamp Sampling非選択の際は、BWの調整により、最短TEとなるポイントを探す。(DWI Optionは固定して最短TEを探る)

分解能を向上させたい時はPhaseで稼ぐのが得策(現在、256まで入力可能)

Phase matrix固定でPhase FOVにて歪みを低減すると、分解能が向上する。
(GE社製MR装置特有)それに伴い信号強度低下するのでSNRの確認必要

SIEMENS社製 MRI装置

$$\text{Distortion (mm)} = dFB \text{ (Hz)} \times FOV \text{ (mm)} \times ESP \text{ (msec)} \times \frac{rFOV}{Rf \times nShot}$$

DWIIはSingleのみ

- ・ ESPの確認 (ESP、Fat water shift)
- ・ 設定条件の組み立て (最短ESPの設定、k-space trajectoryの再確認、その他)

ESPの確認

TA: 0:25 PM: FIX PAT: 2 Voxel size: 2.7×2.7×5.0 mm Rel. SNR: 0.71 : epse

Part 1 **Part 2**

Introduction

Bandwidth 2298 Hz/Px

Averaging mode Long term

Multi-slice mode Interleaved

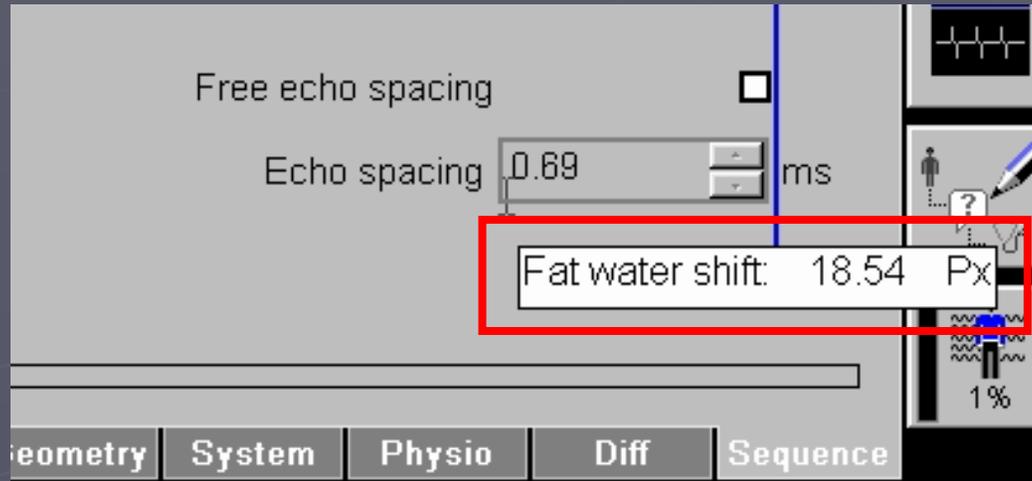
Free echo spacing

Echo spacing 0.53 ms

Bandwidth 752 1002 2298 3256

Program Routine Contrast Resolution Geometry System Physio Inline Sequence

ESPの確認 (Fat water shift)

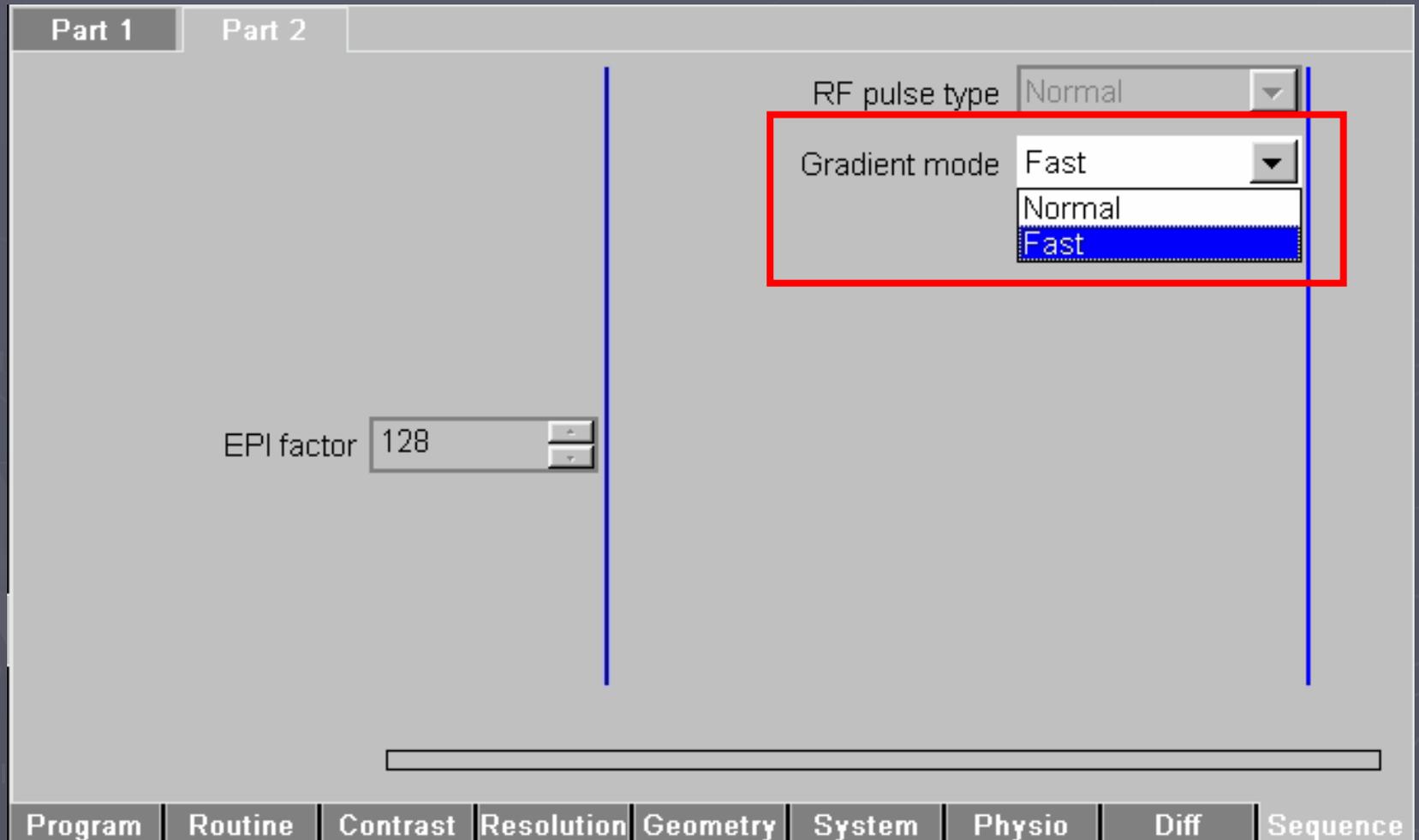


$$\text{Distortion (mm)} = \text{pixel size (mm/pix)} \times \text{Fat water shift (pix)}$$



*Reduction factor*が反映されていないことを認識しておく
(Free echo spacingにチェックが入っているとrFOVも反映されない)

設定条件の組み立て(最短EPSにする)



設定条件の組み立て(最短EPSにする)

TA: 0:25 PM: FIX PAT: 2 Voxel size: 2.7×2.7×5.0 mm Rel. SNR: 0.71 : epse

Part 1 Part 2

Introduction

Bandwidth 2298 Hz/Px

Averaging mode Long term

Multi-slice mode Interleaved

Free echo spacing

Echo spacing 0.53 ms

Bandwidth 752 1002 2298 3256

Program Routine Contrast Resolution Geometry System Physio Inline Sequence

設定条件の組み立て(最短EPSにする)

The screenshot shows a dialog box titled "SAR Information". It displays the current operating mode as "Normal mode (NM)". Below this, there are two buttons for the next measurement: "Normal mode" and "First level". A red rectangle highlights these two buttons. Underneath, a section titled "Displayed values belong to the current patient!" lists SAR values for various body parts: Whole Body, Exposed Body, Head, Head Local, Torso Local, and Legs Local, all showing a value of 0. At the bottom, there is a calculation time of 15:17:44 and a horizontal bar chart for "Whole Body [W/kg]" ranging from 0.0 to 3.8, with the current value at 0.0. The dialog box has a "Close" button and a "Help" button at the bottom.

SAR Information

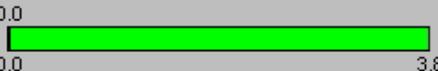
Current operating mode: Normal mode (NM)

Operating mode for the next measurement:

Displayed values belong to the current patient!

Whole Body	<input type="text" value="0"/>	[%]
Exposed Body	<input type="text" value="0"/>	[%]
Head	<input type="text" value="0"/>	[%]
Head Local	<input type="text" value="0"/>	[%]
Torso Local	<input type="text" value="0"/>	[%]
Legs Local	<input type="text" value="0"/>	[%]

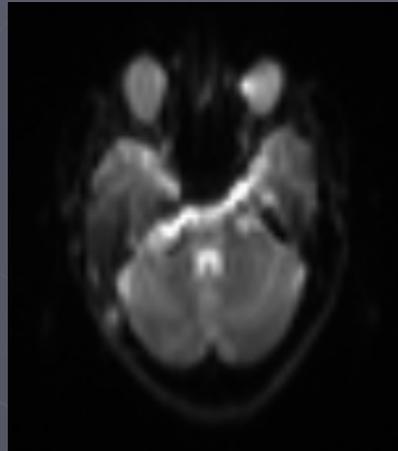
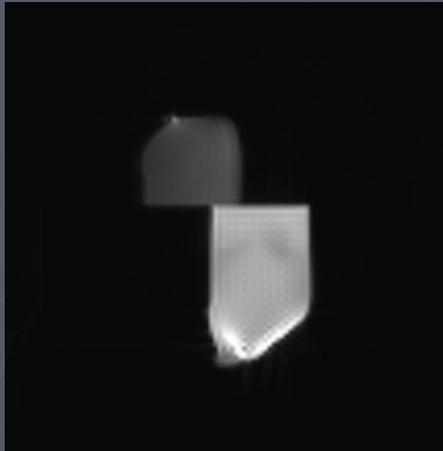
Calculation time: 15:17:44

Whole Body [W/kg]  3.8

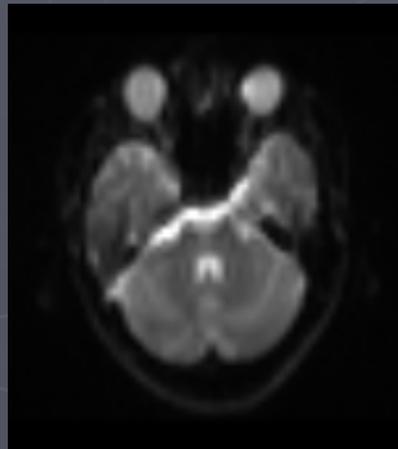
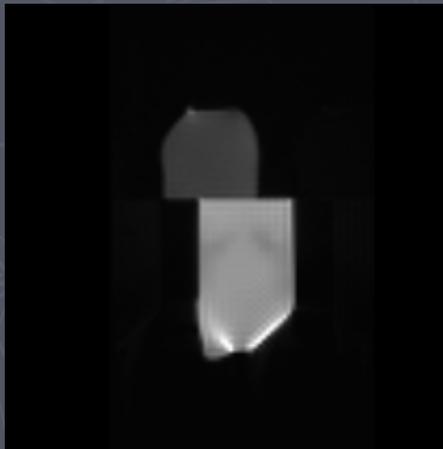
Prediction | Status | Patient | Protocol | Current

設定条件の組み立て(k-space trajectoryの再確認)

100%



50%



—rectangular FOV—

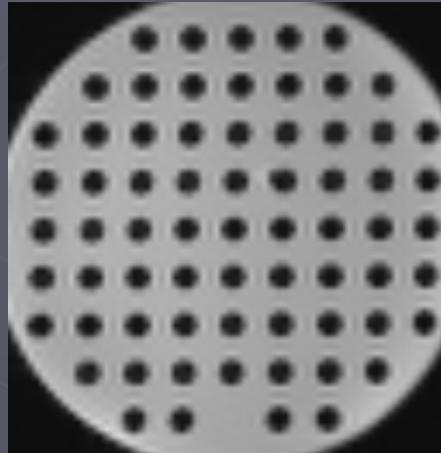
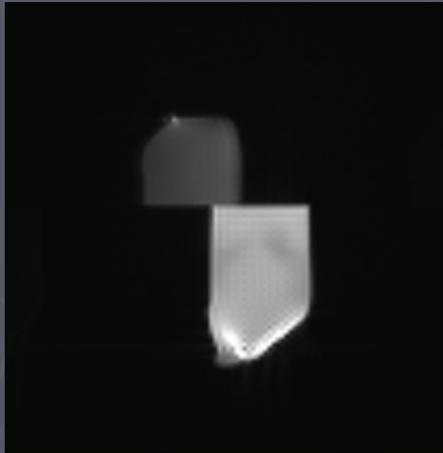
FoV read	350	mm
FoV phase	100.0	%
Slice thickness	5.0	mm
TR	3000	ms
TE	88	ms
Averages	4	
Concatenations	1	
Filter	Raw filter, Distortion...	
coil elements	HE2,4	

350 500

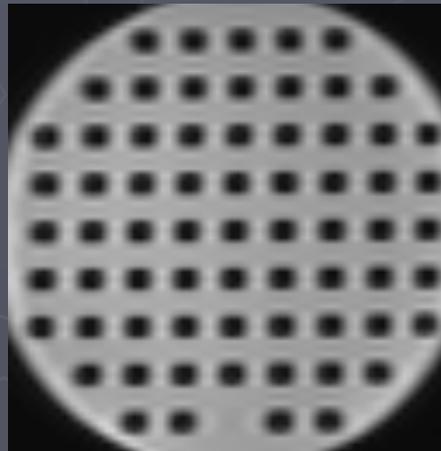
System | Physio | Diff | Sequence

設定条件の組み立て(k-space trajectoryの再確認)

100%



50%



—Rectangular Pixel—

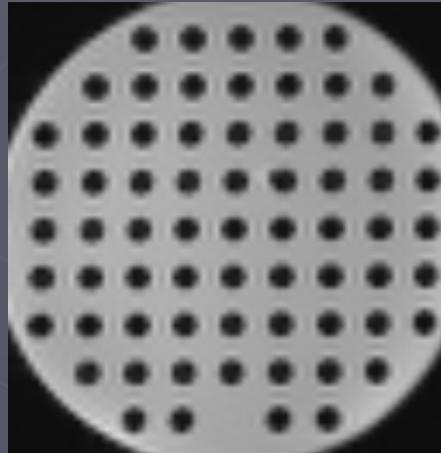
Common	iPAT	Filter
FoV read	350	mm
FoV phase	100.0	%
Slice thickness	5.0	mm
Base resolution	128	
Phase resolution	100	%
Phase partial Fourier	Off	

Phase resolution
47

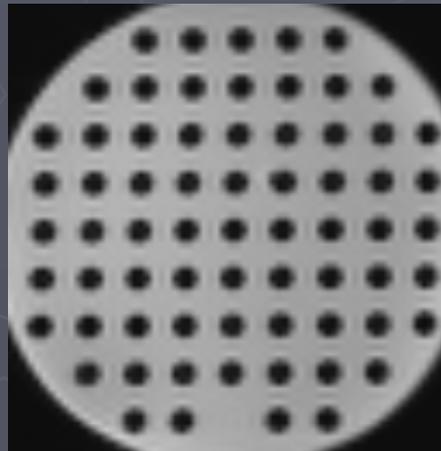
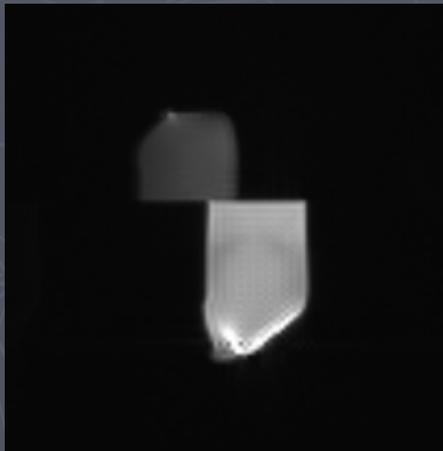
Program | Routine | Contrast | Resolution | Geo

設定条件の組み立て(k-space trajectoryの再確認)

off



5/8



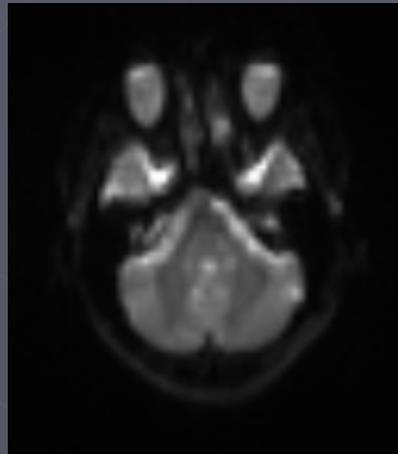
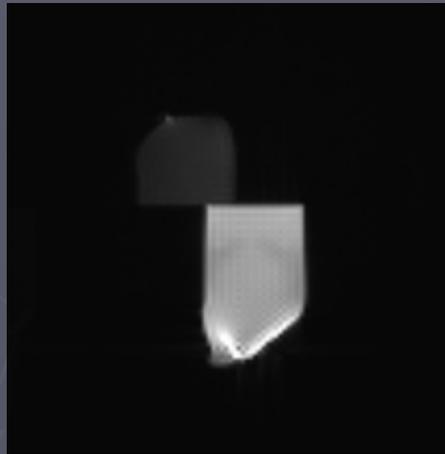
—Phase partial Fourier—

Common	iPAT	Filter
FoV read	350	mm
FoV phase	100.0	%
Slice thickness	5.0	mm
Base resolution	128	
Phase resolution	100	%
Phase partial Fourier	Off	

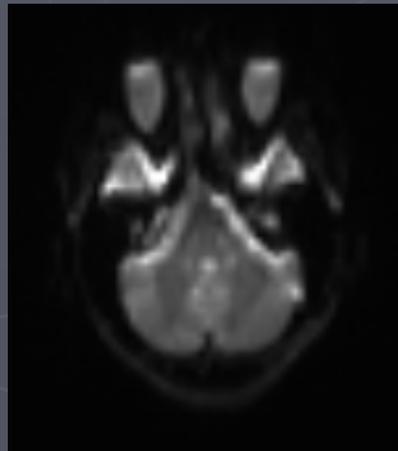
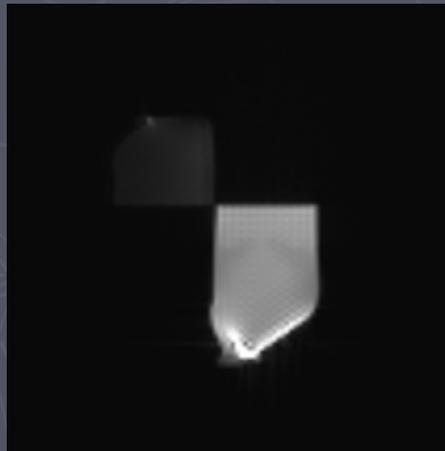
Program | Routine | Contrast | Resolution | Geo

設定条件の組み立て(k-space trajectoryの再確認)

0%



50%



—Phase oversampling—

Phase oversampling control panel:

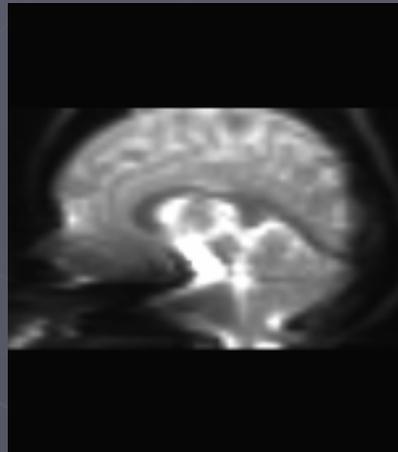
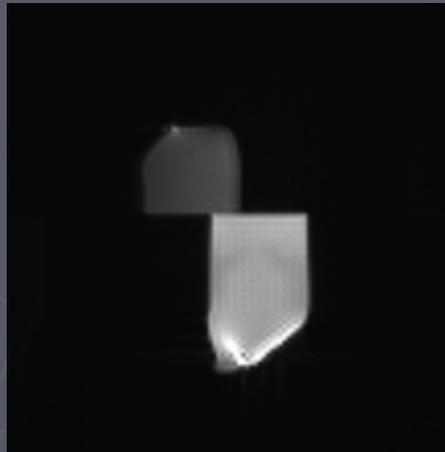
- Slice group: 1
- Slices: 1
- Dist. factor: 30 %
- Position: Isocenter
- Orientation: Transversal
- Phase enc. dir.: R >> L
- Phase oversampling: 0 %** (highlighted in red)

FoV phase: 25.0

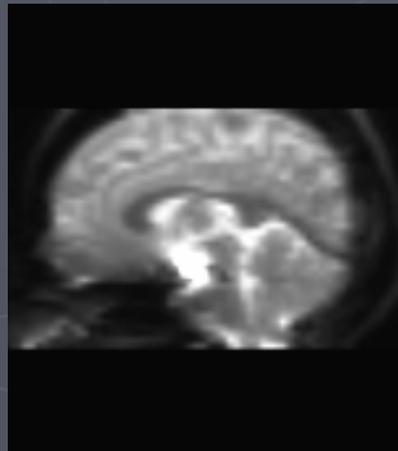
Program | Routine | Contrast | Resolution | Ge

設定条件の組み立て(k-space trajectoryの再確認)

(-)



factor2



—parallel imaging—

Common | iPAT | Filter

PAT mode GRAPPA

Accel. factor PE 2

Max. recomm. factor PE 2

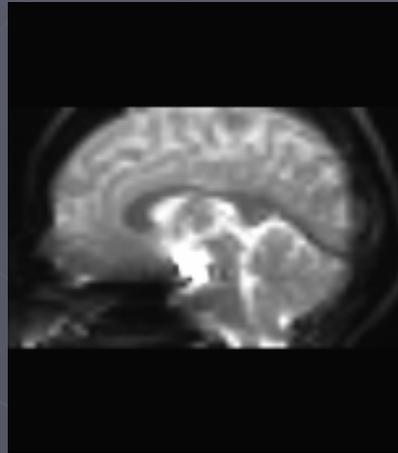
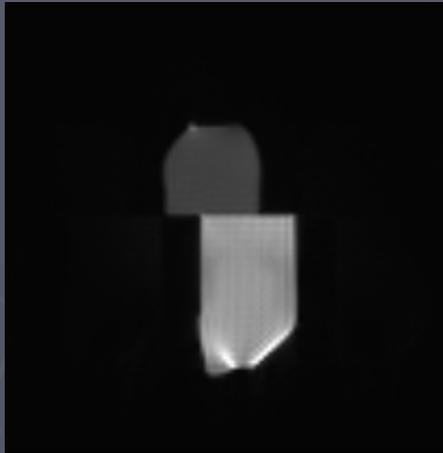
Ref. lines PE 24

Ref. lines PE 12 / 24

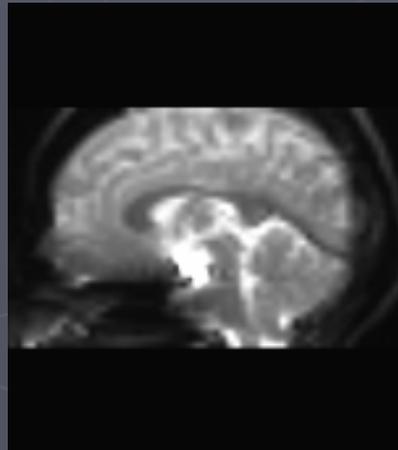
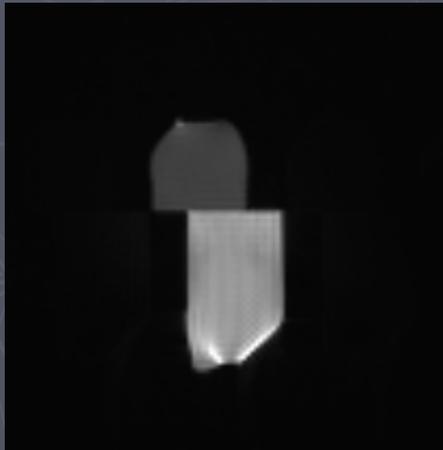
Program | Routine | Contrast | Resolution

設定条件の組み立て(k-space trajectoryの再確認)

ref.30



ref.64



—parallel imaging—

Common | iPAT | Filter

PAT mode GRAPPA

Accel. factor PE 2

Max. recomm. factor PE 2

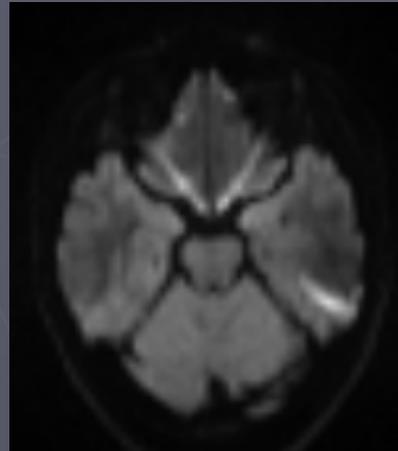
Ref. lines PE 24

Ref. lines PE 12 24

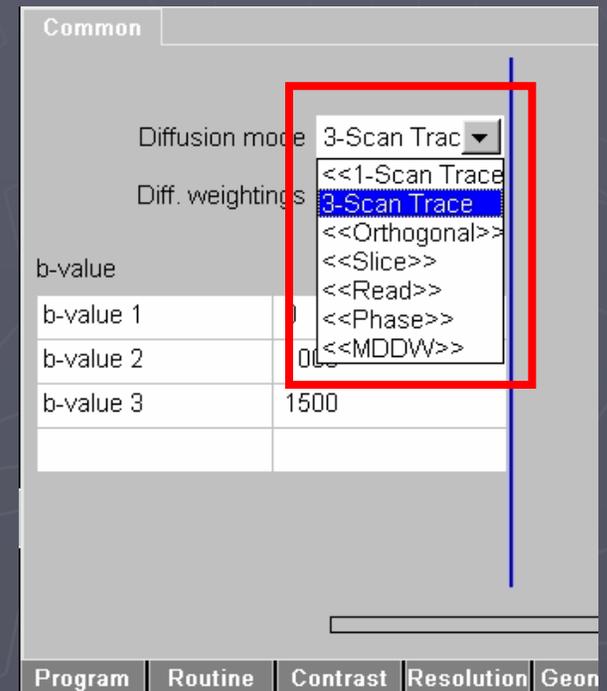
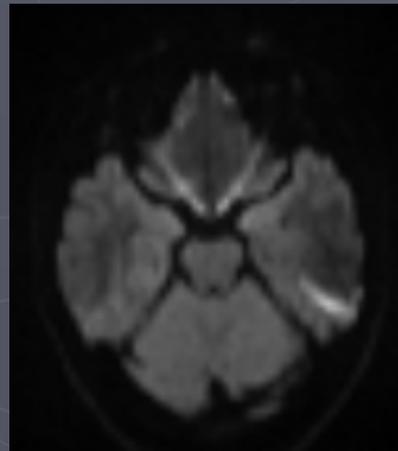
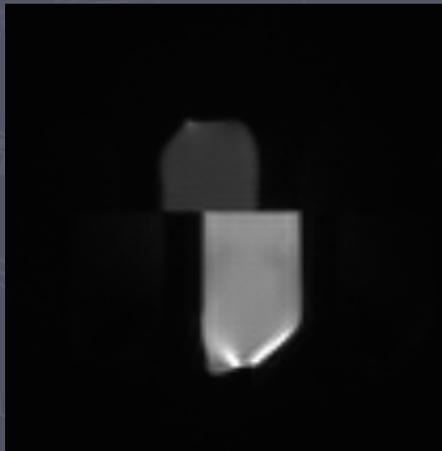
Program | Routine | Contrast | Resolution

設定条件の組み立て(その他)

3-scan trace
TE68



Orthogonal
TE80



SIEMENS社製MR装置のまとめ

撮像領域(FOV)、Frequency matrix 決定後、Phase FOV、mSENSE及びGRAPPAにより歪み低減が行える際は設定し、fast Gradient modeにて最短ESPとなるバンド幅を選択する。

iPATのreference line数は歪みに関係しないため、最大入力することで展開エラーの減少とSNRの向上が期待できる。(SIEMENS社製MR装置特有)

「3-scan trace」、「Orthogonal」はEPIモジュール前のOptionであり、ESPに変化なし。

PHILIPS社製 MRI装置

$$\text{Distortion (mm)} = d\text{FB (Hz)} \times \text{FOV (mm)} \times \text{ESP (msec)} \times \frac{r\text{FOV}}{Rf \times n\text{Shot}}$$

- ・ *ESPの確認(位相方向のバンド幅から換算、WFS)*
- ・ *設定条件の組み立て(最短ESPの設定、k-space trajectoryの再確認、その他)*

ESPの確認(位相方向のバンド幅)

ACQ voxel MPS (mm)	2.73 / 2.73 / 5.00
REC voxel MPS (mm)	2.73 / 2.73 / 5.00
Scan percentage (%)	100
Packages	1
Min. slice gap (mm)	5
Act. slice gap (mm)	0.5
EPI factor	67
WFS (pix) / BW (Hz)	9.278 / 23.4
BW in EPI freq. dir. (Hz)	2440.6
Min. TR (ms)	47
SAR / whole body	< 1% / 0.0 W/kg
Whole body / level	0.0 W/kg / normal
B1 rms [uT]	0.4
PNS / level	77% / normal



$$bBW \text{ (Hz/pixel)} = 1 / (\text{ESP} \times \text{Phase matrix})$$

ESPの確認(WFS)

ACQ voxel MPS (mm)	2.73 / 2.73 / 5.00
REC voxel MPS (mm)	2.73 / 2.73 / 5.00
Scan percentage (%)	100
Packages	1
Min. slice gap (mm)	5
Act. slice gap (mm)	0.5
EPI factor	67
WFS (pix) / BW (Hz)	9.278 / 23.4
BW in EPI freq. dir. (Hz)	2440.6
Min. TR (ms)	47
SAR / whole body	< 1% / 0.0 W/kg
Whole body / level	0.0 W/kg / normal
B1 rms [uT]	0.4
PNS / level	77% / normal

$$\text{Distortion (mm)} = \text{pixel size (mm/pix)} \times \text{WFS (pix)}$$

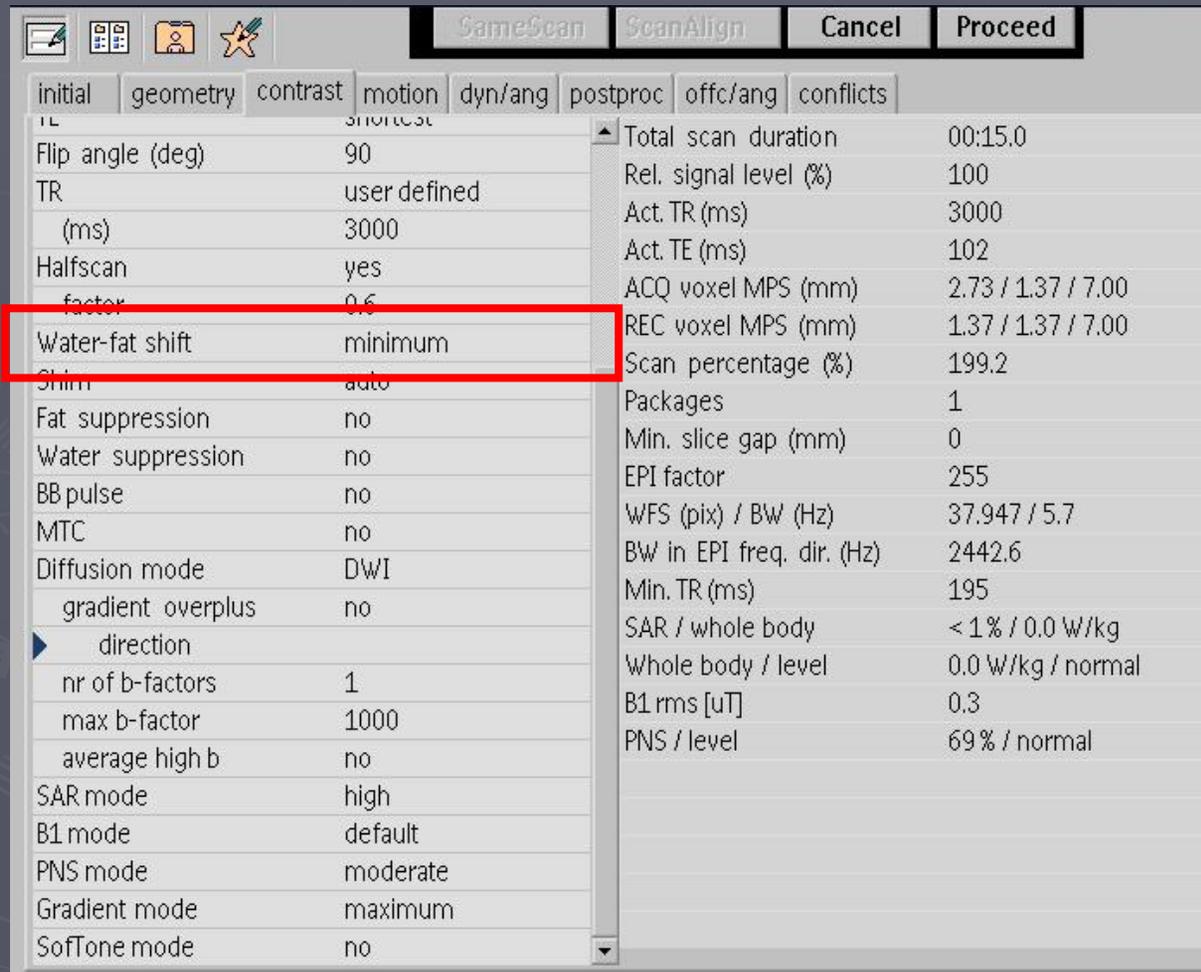
設定条件の組み立て(最小WFSまたは、最大BWにする)

The screenshot shows a software interface for setting MRI parameters. The 'initial' tab is selected. The parameters are organized into two columns. The left column lists parameters like Flip angle, TR, Halfscan factor, etc. The right column lists parameters like Total scan duration, Rel. signal level, etc. The 'B1 mode' and 'PNS mode' rows are highlighted with a red box.

Parameter	Value
Flip angle (deg)	90
TR (ms)	3000
Halfscan factor	0.6
Water-fat shift	minimum
Shim	auto
Fat suppression	no
Water suppression	no
BB pulse	no
MTC	no
Diffusion mode	DWI
gradient overplus	no
direction	
nr of b-factors	1
max b-factor	1000
average high b	no
SAR mode	high
B1 mode	dc fault
PNS mode	moderate
Gradient mode	maximum
SoftTone mode	no

Parameter	Value
Total scan duration	00:15.0
Rel. signal level (%)	100
Act. TR (ms)	3000
Act. TE (ms)	102
ACQ voxel MPS (mm)	2.73 / 1.37 / 7.00
REC voxel MPS (mm)	1.37 / 1.37 / 7.00
Scan percentage (%)	199.2
Packages	1
Min. slice gap (mm)	0
EPI factor	255
WFS (pix) / BW (Hz)	37.947 / 5.7
BW in EPI freq. dir. (Hz)	2442.6
Min. TR (ms)	195
SAR / whole body	< 1% / 0.0 W/kg
Whole body / level	0.0 W/kg / normal
B1 rms [uT]	0.3
PNS / level	69% / normal

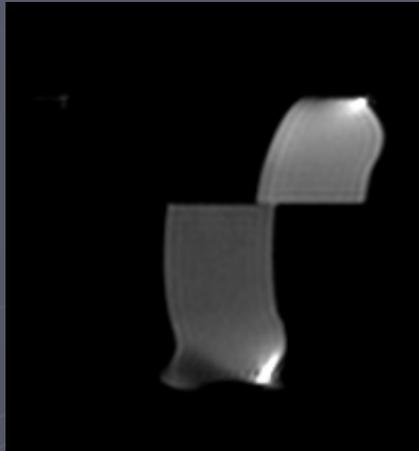
設定条件の組み立て(最小WFSまたは、最大BWにする)



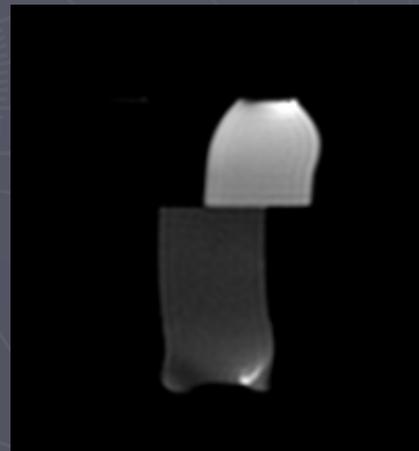
設定条件の組み立て(k-space trajectoryの再確認)

—rectangular FOV—

100%



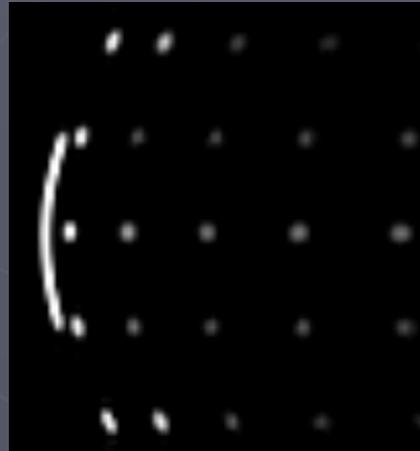
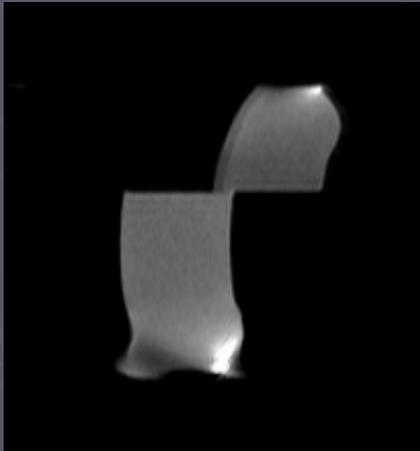
50%



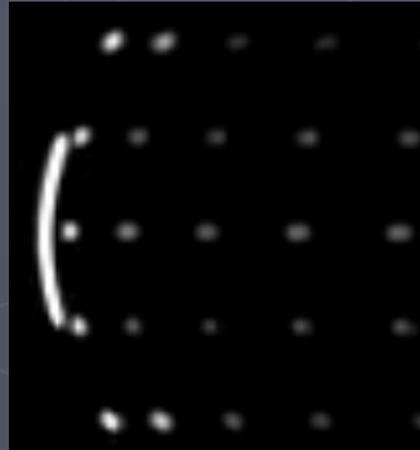
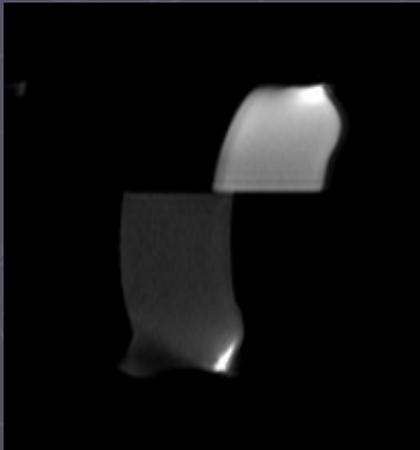
initial	geometry	contrast	motion	dyn/ang	post
FOV (mm)	350				
RFOV (%)	100				
Fold-over suppression	no				
Matrix scan	128				
reconstruction	128				
Scan percentage (%)	100				
SENSE	yes				
P reduction (RL)	2				
P os factor	1				
k-t BLAST	no				
Stacks	1				
type	parallel				
slices	1				
slice thickness (mm)	5				
slice gap	default				
slice orientation	transverse				
fold-over direction	RL				
fat shift direction	L				

設定条件の組み立て(k-space trajectoryの再確認)

no



0.6



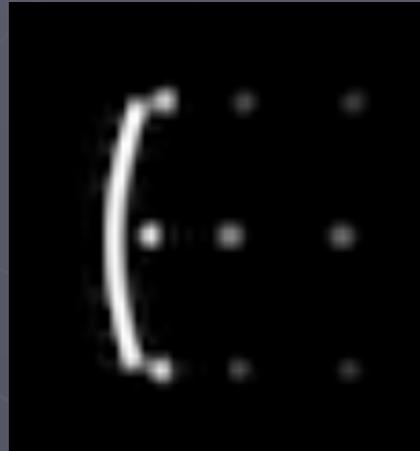
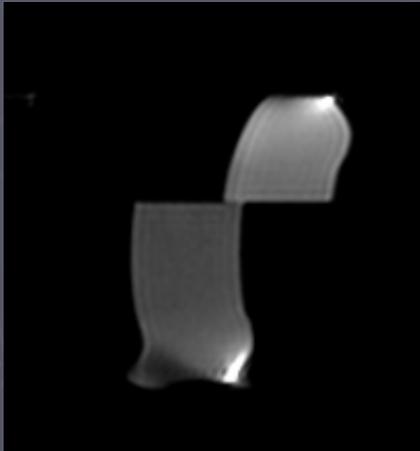
—Phase partial Fourier—

SameScan

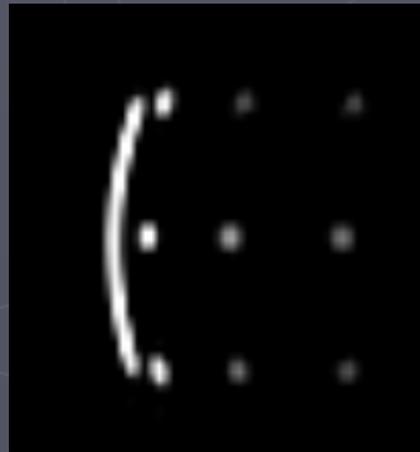
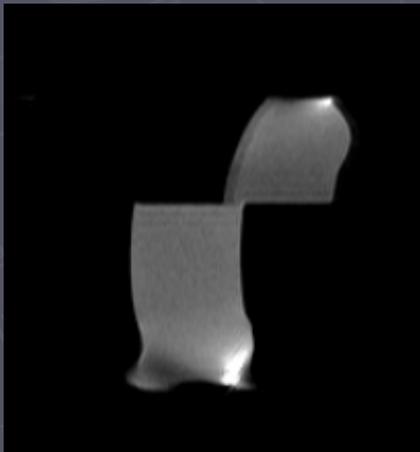
initial	geometry	contrast	motion	dyn/ang	postp
partial echo		no			
TE		shortest	(user d...		
Flip angle (deg)		90			
TR		user defined	(sh...		
(ms)		4000	(4000)		
Halfscan		yes			
factor		0.6			
water-fat shift		minimum			
Shim		auto			
Fat suppression		SPIR			
strength		strong			
frequency offset		default			
Water suppression		no			
BB pulse		no			
MTC		no			
Diffusion mode		DWI			
gradient overplus		no	(yes)		

設定条件の組み立て(k-space trajectoryの再確認)

100%



200%



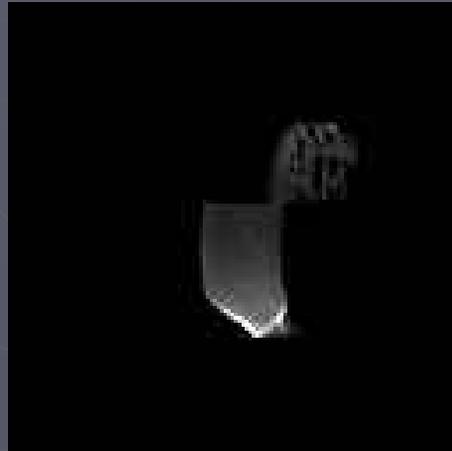
—Rectangular Pixel—

SameScan

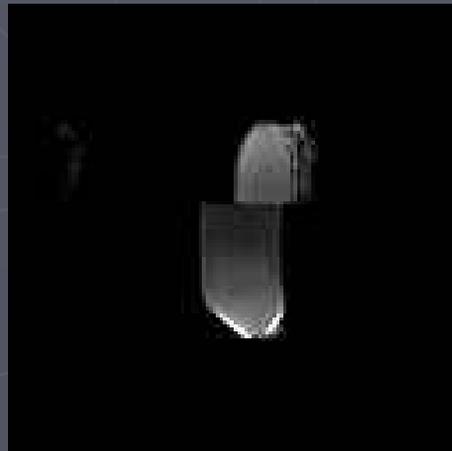
initial	geometry	contrast	motion	dyn/ang	post
FOV (mm)			350		
RFOV (%)			100		
Fold-over suppression			no		
Matrix scan			128		
reconstruction			128		
Scan percentage (%)			100		
SENSE			yes		
P reduction (RL)			2		
Pos factor			1		
k-t BLAST			no		
Stacks			1		
type			parallel		
slices			1		
slice thickness (mm)			5		
slice gap			default		
slice orientation			transverse		
fold-over direction			RL		
fat shift direction			L		

設定条件の組み立て(k-space trajectoryの再確認)

SENSE(-)



P reduction 2

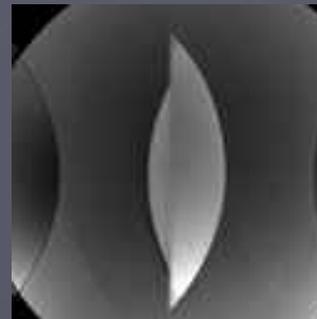
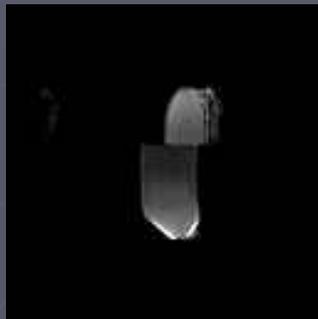


—parallel imaging—

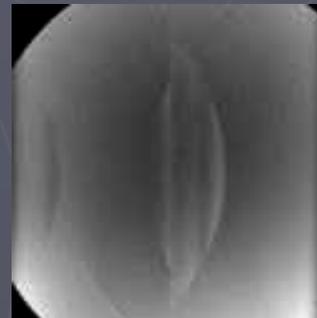
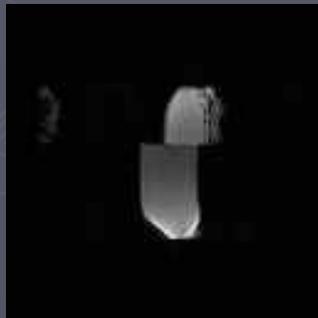
SameScan					
initial	geometry	contrast	motion	dyn/ang	post
FOV (mm)	350				
RFOV (%)	100				
Fold-over suppression	no				
Matrix scan	128				
reconstruction	128				
Scan percentage (%)	100				
SENSE	yes				
P reduction (RL)	2				
P os factor	1				
k-t BLAST	no				
Stacks	1				
type	parallel				
slices	1				
slice thickness (mm)	5				
slice gap	default				
slice orientation	transverse				
fold-over direction	RL				
fat shift direction	L				

設定条件の組み立て(k-space trajectoryの再確認)

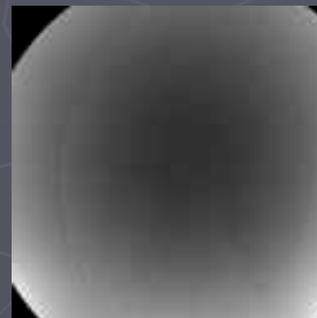
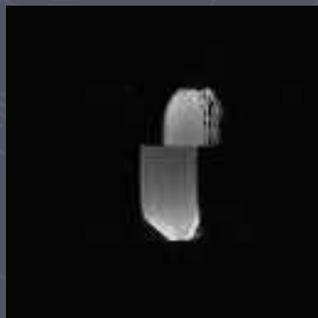
(-)



(+),1NEX



(+),2NEX

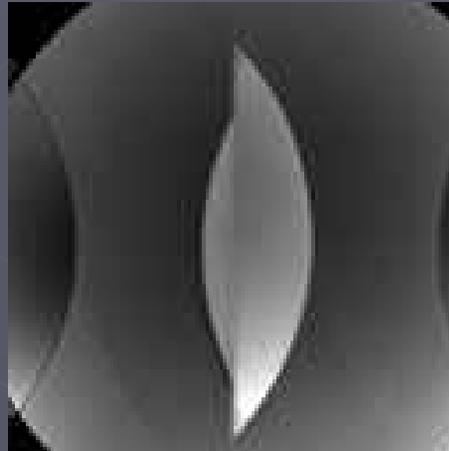
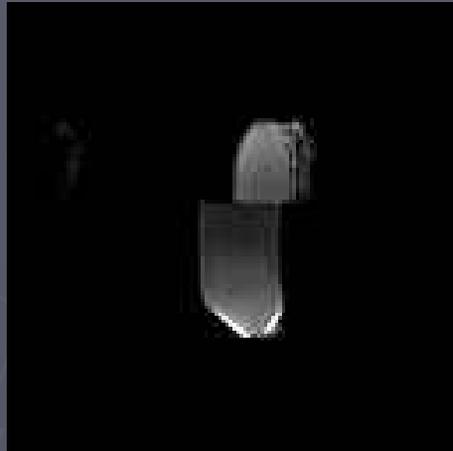


—Phase oversampling—

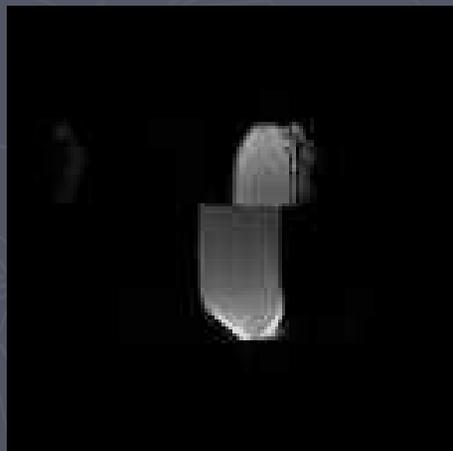
Parameter	Value
FOV (mm)	350
RFOW (%)	100
Fold-over suppression	no
Matrix scan	128
reconstruction	128
Scan percentage (%)	100
SENSE	yes
P reduction (RL)	2
Pos factor	1
k-t BLAST	no
Stacks	1
type	parallel
slices	1
slice thickness (mm)	5
slice gap	default
slice orientation	transverse
fold-over direction	RL
fat shift direction	L

設定条件の組み立て(k-space trajectoryの再確認)

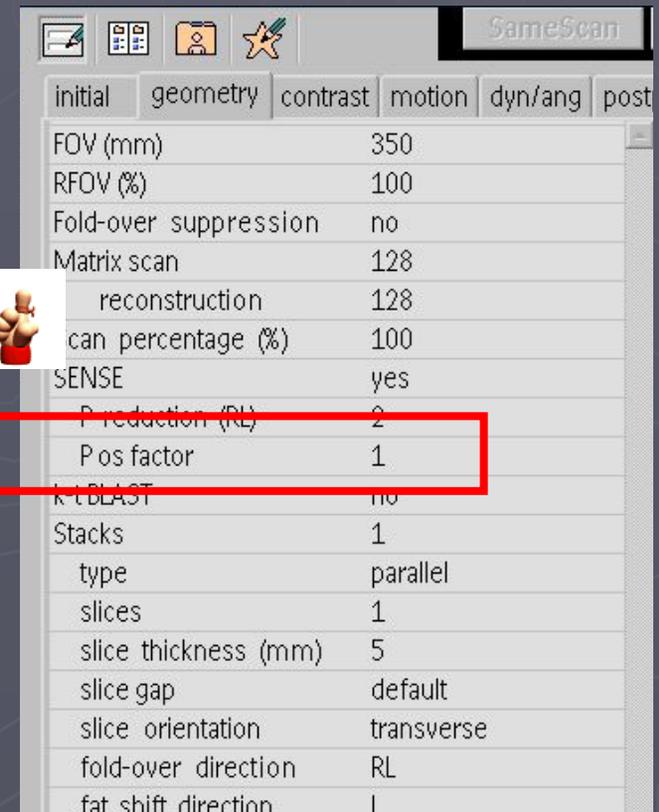
1



2



—Phase oversampling—



initial	geometry	contrast	motion	dyn/ang	post
FOV (mm)			350		
RFOV (%)			100		
Fold-over suppression			no		
Matrix scan			128		
reconstruction			128		
scan percentage (%)			100		
SENSE			yes		
P reduction (RL)			2		
Pos factor			1		
k-CLBLAST			no		
Stacks			1		
type			parallel		
slices			1		
slice thickness (mm)			5		
slice gap			default		
slice orientation			transverse		
fold-over direction			RL		
fat shift direction			L		

設定条件の組み立て(k-space trajectoryの再確認)

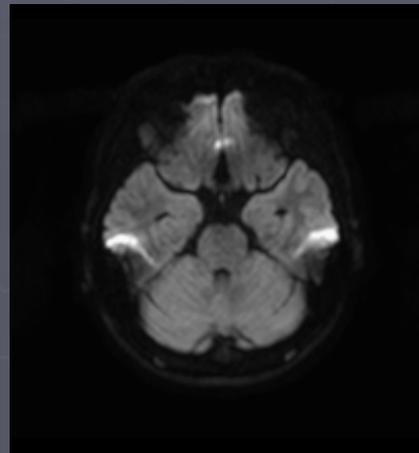
—nShot—

The screenshot shows a settings dialog box for 'nShot' with several tabs: 'initial', 'geometry', 'contrast', 'motion', 'dyn/ang', 'postproc', 'offc/ang', and 'conflicts'. The 'initial' tab is active. The settings are organized into two columns. The left column contains parameters like 'Scan mode', 'technique', 'Modified SE', 'Acquisition mode', 'Fast Imaging mode', 'shot mode', 'EPI factor', 'Echoes', 'partial echo', 'TE (ms)', and 'Flip angle (deg)'. The right column contains parameters like 'Total scan duration', 'Rel. signal level (%)', 'Act. TR (ms)', 'Act. TE (ms)', 'ACQ voxel MPS (mm)', 'REC voxel MPS (mm)', 'Scan percentage (%)', 'Packages', 'Min. slice gap (mm)', 'Optimal slices', 'Max. slices', and 'Entered heartrate'. A red rectangle highlights the 'shot mode' (multishot) and 'EPI factor' (15) settings.

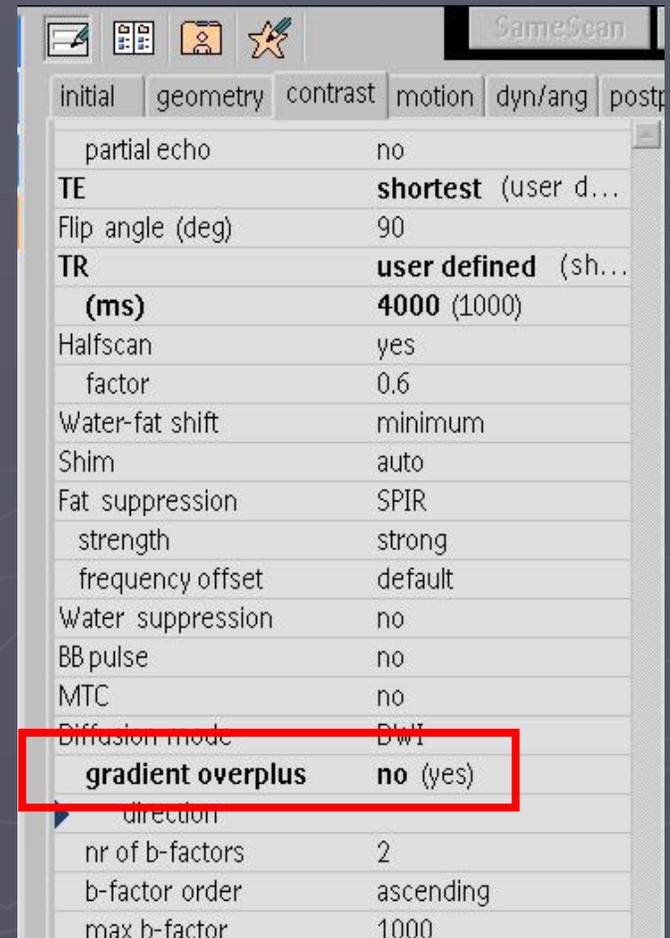
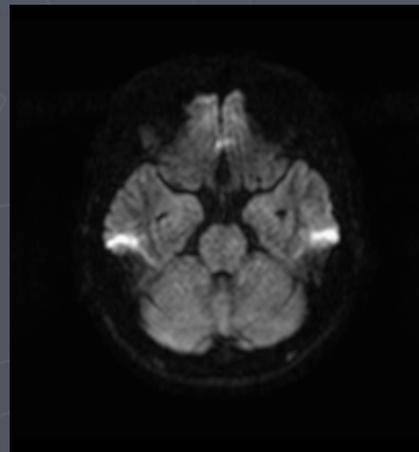
Parameter	Value	Parameter	Value
Scan mode	MS	Total scan duration	03:30.0
technique	SE	Rel. signal level (%)	100
Modified SE	no	Act. TR (ms)	3000
Acquisition mode	cartesian	Act. TE (ms)	93
Fast Imaging mode	EPI	ACQ voxel MPS (mm)	1.80 / 2.64 / 5.00
shot mode	multishot	REC voxel MPS (mm)	0.90 / 0.90 / 5.00
EPI factor	15	Scan percentage (%)	68.2
Echoes	1	Packages	2
partial echo	no	Min. slice gap (mm)	0
TE (ms)	10	Optimal slices	15
Flip angle (deg)	90	Max. slices	30
		Entered heartrate	60

設定条件の組み立て(その他)

gradient overplus
TE67



(-)
TE84



parameter	value
partial echo	no
TE	shortest (user d...)
Flip angle (deg)	90
TR	user defined (sh...)
(ms)	4000 (1000)
Halfscan	yes
factor	0.6
Water-fat shift	minimum
Shim	auto
Fat suppression	SPIR
strength	strong
frequency offset	default
Water suppression	no
BB pulse	no
MTC	no
Diffusion mode	DWI
gradient overplus	no (yes)
direction	
nr of b-factors	2
b-factor order	ascending
max b-factor	1000

PHILIPS社製MR装置のまとめ

撮像領域(FOV)、Frequency matrix 決定後、Phase FOVおよびSENSEにより歪み低減が行える際は設定し、PNS modeをhigh、Gradient modeをmaximum、さらにWater-fat shiftをminimumを選択することで最短ESPとなる。

Phase over samplingを使用しても歪みは変化しない。(PHILIPS社製MR装置特有)

同期を併用することでmulti shotで撮像できる。(PHILIPS社製MR装置特有)

「gradient overplus」、はEPIモジュール前のOptionであり、ESPに変化なし。

まとめ

SE-EPI (DWI)における位相方向への歪みが最小となるように各社において重要となるパラメータの設定について解説した。



実際の臨床においては最短ESPが最も良好な画像となるとは限らない。



パラメータのひとつとして認識が必要

長野県MR研究会 II

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