

## Sequence Installation

1. Copy the file '**multiBandsEPI\_6.0.1.PvUserBinMethod**' to the disk of your Bruker system. Open the **ParaVision 6.0.1** and click '**File**'->'**Import**'->'**Binary Method**' and select '**multiBandsEPI\_6.0.1.PvUserBinMethod**' on the path where you put.
2. Copy all the RF Waveforms (\*.exc files) to the **ParaVision** system. The wave folder path is '**....->PV6.0.1->exp->stan->nmr->lists->wave**'.

## Scanning parameters

### 1. MB Mode

Change the 'MB Mode' to select MB Factors (MBF), e.g. the 'Bi-Bands' is for an MBF=2 experiment; the 'Tri-Bands' is for an MBF=3 experiment.

The screenshot shows the ParaVision 6.0.1 sequence setup window. The 'MB Mode' is set to 'Bi-Bands'. Other parameters include Echo Time (15.000 ms), Repetition Time (1000.000 ms), Averages (10), Repetitions (5), Scan Time (0h0m50s0ms), Segments (1), Signal Type (Fid), Bandwidth (300000.0 Hz), Band Spacing Factor (1.00), Slice Package (1 of 1), Slices (1), Slice Orientation (Axial), Read Orientation (Le-Rt), Slice Thickness (0.400 mm), Image Size (80 x 60), Field of View (20.000 x 15.000 mm), CAIPIRINHA Mode (checked), Reference Scan (checked), Sine Readout (unchecked), and View Mode (Regular). The bottom of the window has tabs for Routine, Contrast, Resolution, Reference RF, Geometry, Sequence, Setup, System, Single Parameter, and Instruction.

### 2. View Mode

For some cases TOPUP distortion correction is required. The '**View Mode**' is the way of EPI echo train phase encoding. The '**Regular**' is blipping up; The '**Reverse**' is blipping down; The '**Alternate**' is blipping up for even # frames and blipping down for odd # frames.

### 3. Sine Readout

To reduce acoustic noise of EPI scanning, select '**Sine Readout**' to change the trapezoid readout gradient waveforms to be sinuous.

#### 4. CAPIRINHA Mode

Phase chopping MB slices obtained to reduce g-factors. It is strongly recommended to keep selecting **CAPIRINHA Mode** always.

#### 5. Reference Scan

Switch on the 'Reference Scan' is for a reference scan; switch off the 'Reference Scan' is for an fmri scan. **The reference scan data is required for any fmri scan data reconstruction. All the scanning parameters should be the same.**

#### 6. RF Waveforms

All RF waveforms have to be designed, made and manually set by user. Technically, the RF waveform is unable to be dynamically generated yet **The MB Factor, MB slice number and slice gap ratio must consistent with the MB RF waveforms used. Slice thickness and gap can be adjusted.** If  $MBF = N$ , it is required to set  $N+2$  RF waveforms (1 MB RF and  $N+1$  SB Reference RF). **The pulse length and flip angle of all RF waveforms should be the same.**

The screenshot shows a software interface with a tabbed menu at the top: 'RF Selection', 'RF Attenuation', 'RF Power', and 'RF Amplitude'. The 'RF Selection' tab is active. Below the tabs, there are three rows of selection fields, each with a label on the left and a dropdown menu on the right. The rows are labeled 'Reference RF00', 'Reference RF01', and 'Reference RF02'. The dropdown menus are currently set to 'MB2x1.6NoGapRFRefSB00', 'MB2x1.6NoGapRFRefSB01', and 'MB2x1.6NoGapRFRefSB02' respectively. A red rectangular box highlights these three rows. At the bottom of the interface, there is a horizontal bar with several tabs: 'Routine', 'Contrast', 'Resolution', 'Reference RF', 'Geometry', 'Sequence', 'Setup', 'System', 'Single Parameter', and 'Instruction'. The 'Reference RF' tab is currently selected.

Reference RF	Selected Waveform
Reference RF00	MB2x1.6NoGapRFRefSB00
Reference RF01	MB2x1.6NoGapRFRefSB01
Reference RF02	MB2x1.6NoGapRFRefSB02

Main | EPI | Frequency Ch.1 | Transmit Ch.1

Measuring Method: User:multiBandsEPI

Bandwidth: 300000.0 Hz

Signal Type: ☒ Fid ☐ Spin Echo

Segments: 1

MB Excitation Pulse: MB2x16NoGapRF

☒ Auto Slice Spoiler

Minimum TE: 11.355

☐ Technologists Mode

Routine | Contrast | Resolution | Reference RF | Geometry | Sequence | Setup | System | Single Parameter | Instruction

**Pulse Details (RefRF00)**

Length: 1.0000 ms

Bandwidth: 4400.0 Hz

Flipangle: 45.0 °

☐ Calculated

Sharpness: 3

Bwfac: 4400.000000 Hz.ms

Sint: 0.253100

Pint: 0.198956

Type: 0

Rpfac: 50.000000 %

Pow: 0.251200 W

Shape: MB2x16NoGapRFRefSB00.exc

Close

**Pulse Details (Excitation Pulse)**

Length: 1.0000 ms

Bandwidth: 4400.0 Hz

Flipangle: 45.0 °

☐ Calculated

Sharpness: 3

Bwfac: 4400.000000 Hz.ms

Sint: 0.126550

Pint: 0.099478

Type: 0

Rpfac: 50.000000 %

Pow: 0.251200 W

Shape: MB2x16NoGapRF.exc

Close

## Scanning Example

An example was shown below: MB RF waveform parameters were used MBF =2, slice number = 32, slice gap ratio = 0.2.

### 1. Reference scan

Switch on '**Reference Scan**', set all scanning parameter e.g. TR/TE Bandwidth, FOV, Matrix resolution, Shimming and under sampling parameters (e.g. Zero Filling, Partial Fourier or phase encoding GRAPPA) , The '**Repetition #**' is fixed for reference scan. **For the reference scan, it is strongly recommended to add the signal averaging # to improve reconstruction quality.** In this example, we set the average # to be 10. For MBF =2, slice number = 32, the slice number is set to be 16 (Slice

number/MBF). If the slice thickness is 0.4 mm, set the slice gap to be 0.08 mm (slice thickness  $\times$  slice gap ratio).

Echo Time: 15.000 ms  
 Repetition Time: 1000.000 ms  
 Averages: 10  
 Repetitions: 5  
 Scan Time: 0h0m50s0ms  
 Segments: 1  
 Signal Type: ☒ Fid ☐ Spin Echo  
 Bandwidth: 300000.0 Hz  
 Band Spacing Factor: 19.20  
 MB Mode: Bi-Bands  
 Slice Package: 1 of 1  
 Slices: 16  
 Slice Orientation: ☒ Axial ☐ Sagittal ☐ Coronal  
 Read Orientation: ☒ Le-Rt ☐ V-D ☐ Ro-Cd  
 Slice Thickness: 0.400 mm  
 Image Size: 80 x 60  
 Field of View: 20.000 x 15.000 mm  
☒ CAIPIRINHA Mode  
☒ Reference Scan  
☐ Sine Readout  
 View Mode: ☒ Regular ☐ Reverse ☐ Alternate

Routine Contrast Resolution Reference RF Geometry Sequence Setup System Single Parameter Instruction

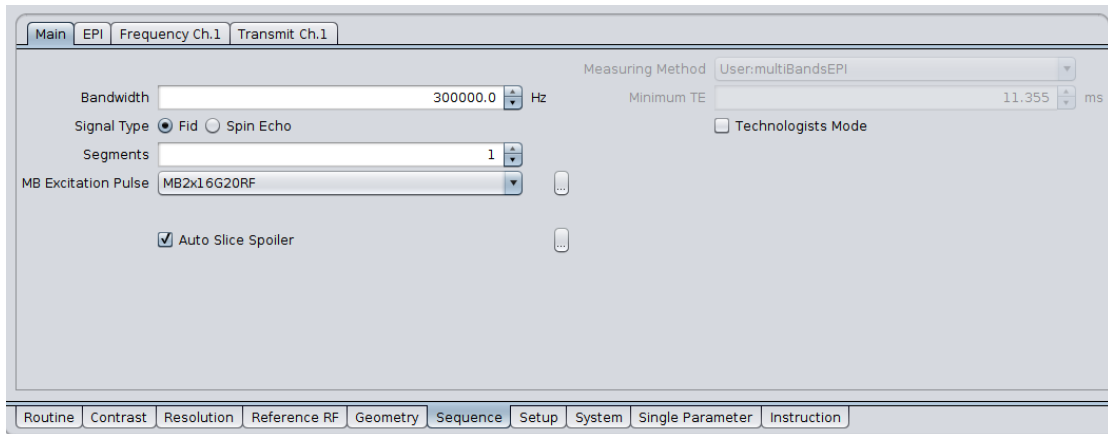
Slice Thickness: 0.400 mm  
 Object Ordering Mode: Interlaced  
☐ Only Main Orientations  
 Field of View: 20.000 x 15.000 mm  
 Anti Aliasing: 1.000 x 1.000  
 Slice Package: 1 of 1  
 Slices: 16  
 Slice Orientation: ☒ Axial ☐ Sagittal ☐ Coronal  
 Read Orientation: ☒ Le-Rt ☐ V-D ☐ Ro-Cd  
 Read Offset: 0.000 mm  
 Phase Offset: 0.000 mm  
 Slice Offset: 0.000 mm  
 Slice Gap Mode: ☐ Contiguous ☒ Non-contiguous  
 Slice Gap: 0.080 mm  
 Slice Distance: 0.480 mm

Routine Contrast Resolution Reference RF Geometry Sequence Setup System Single Parameter Instruction

Set all RF waveforms, for MBF = 2, 1 MB RF and 3 SB reference RF are required to be set. The pulse length and flip angle of all RF waveforms should be the same.

RF Selection RF Attenuation RF Power RF Amplitude  
 Reference RF00: MB2x16G20RFRRefSB00  
 Reference RF01: MB2x16G20RFRRefSB01  
 Reference RF02: MB2x16G20RFRRefSB02

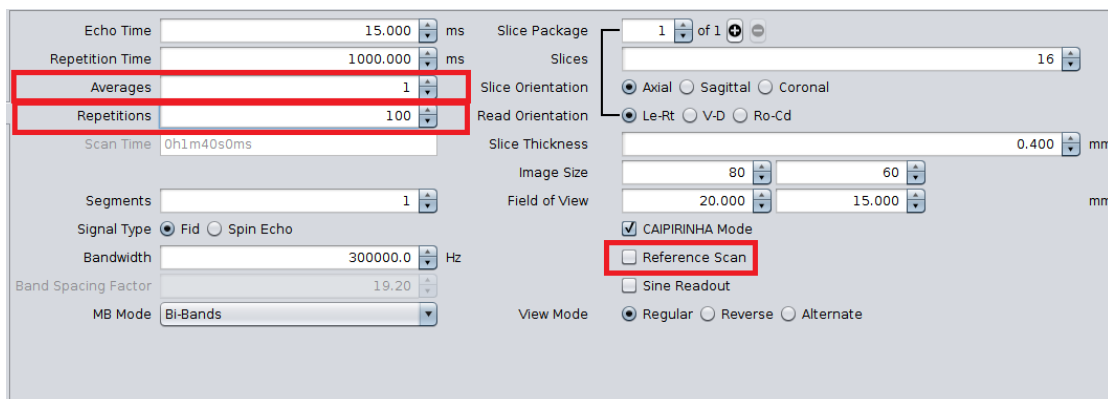
Routine Contrast Resolution Reference RF Geometry Sequence Setup System Single Parameter Instruction



When all is prepared, finish the scan.

## 2. FMRI Scan

Duplicate the scan and switch off the '**Reference Scan**', change the '**Repetition #**' and '**Averages #**'. Finish the scan.



Something about 'View Mode': The **Regular View Mode** Reference scan can only support the **Regular View Mode** Fmri data reconstruction; The **Reverse View Mode** Reference scan can only support the **Reverse View Mode** Fmri data reconstruction; The **Alternate View Mode** Reference scan can support all of the three 'View Mode' Fmri data reconstruction.

## Reconstruction

The reconstruction tools can be run on Microsoft Windows system.

1. Click the '**MBParallelReconVxxx.exe**', if it cannot open please click the '**vc\_redist.x86.exe**' to install Microsoft Visual C++ Runtime libs.

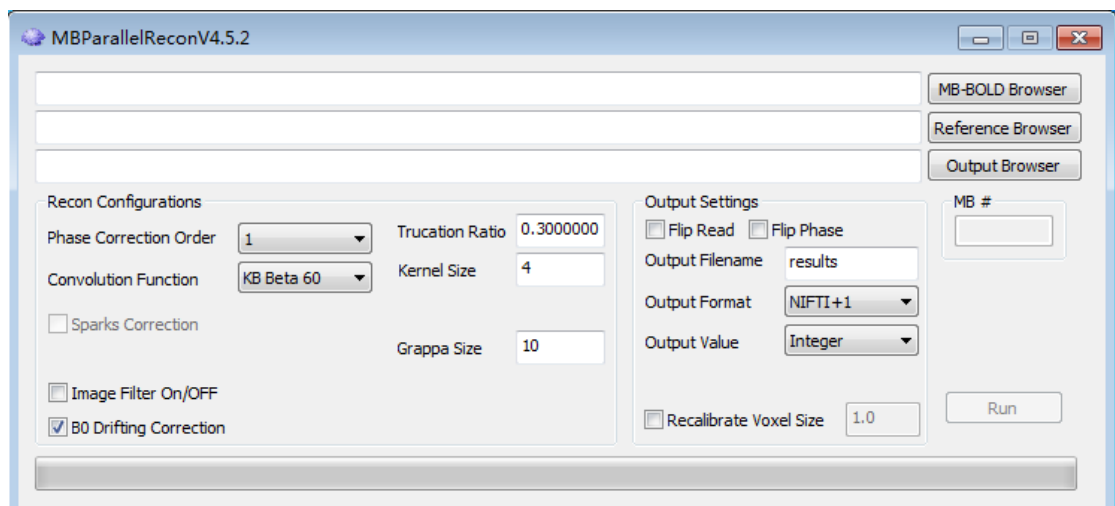
## 2. Instructions of some parameters

**Output Format:** select a results data format. '**No Format**'-- a binary file like as Bruker's '2dseq'; '**Analyze 7.5**'-- output as NIFTI1 format (\*.hdr+\*.img); '**NIFTI+1**' -- output as NIFTI+1 format (\*.nii).

**Recalibrate Voxel Size:** When the '**Output Format**' is selected as '**Analyze 7.5**' or '**NIFTI+1**'. The output voxel size can be recalibrated by change the zooming value.

**Image Filter On/Off:** Switch on the '**Image Filter On/OFF**' and set the '**Filter Width**' value to filter image results. SNR can be improved but also get blurring.

It is recommended that not change other recon parameters unless it is necessary.



## 3. Run the tools.

Click the '**MB-BOLD Browser**' to select a folder containing FMRI data.

Click the '**Reference Browser**' to select a folder containing reference scan data.

Click the '**Output Browser**' to select a path for exporting results.

Choose the '**Output name**', '**Output Format**'. Set the '**Recalibrate Voxel Size**' if it needs.

Click the '**Run**' button and wait till it is done.