Multidimensional diffusion with SPEN acquisition on Bruker Paravision 6.0x - User instructions

**Maxime Yon –** [**maxime.yon@gmail.com**](mailto:maxime.yon@gmail.com)

Multidimensional diffusion tensors is a recent method allowing to disentangle the multiples diffusion components of averaged diffusion tensor within a single MRI voxel. The estimation of the multiple diffusion tensor distributions requires multiple b-weighted images acquired with different diffusion shapes, diffusion directions and b-values leading to long intrinsic acquisition time, low spatial resolution and signal to noise ratio. These instructions will allows you to use SPEN as a robust alternative to Spin Echo EPI to perform ultrafast multidimensional diffusion imaging with much-reduced B0 and B1 inhomogeneities artifacts.

This package contains a fully T2\* refocused version of the SPEN method based on a 180° chirp pulse developed for Bruker MRI systems running Paravision 6.0x on Avance III/IIIHD systems combine with shape gradient required for multidimensional MRI (see pulse programs in figure 1). The method allows single-shot or interleaved/segmented acquisition with single-slice, multi-slice 2D or 3D phase encoded acquisitions and multi echo acquisitions. The sequences work – but of course its use is the operator’s responsibility.

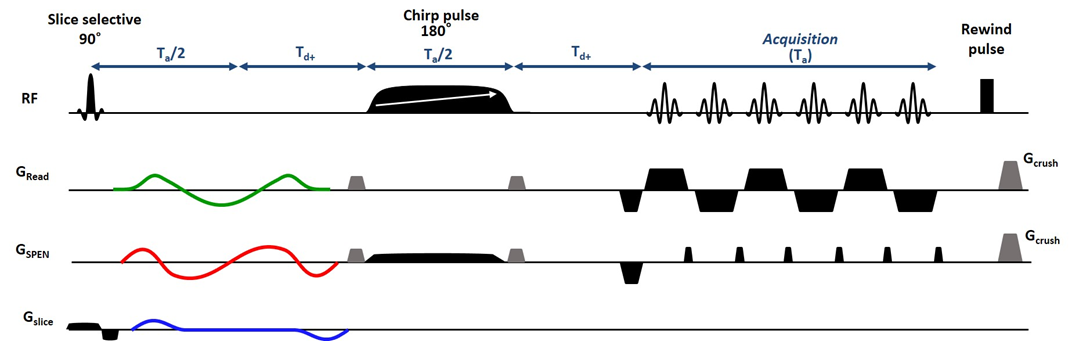


Figure 1: Sequence design for multidimensional diffusion tensors 2D SPEN imaging. The SPEN encoding is performed by a 180˚ chirp pulse acting in the presence of an encoding gradient which replaces the more artifact-prone, low bandwidth EPI dimension. Timings are illustrated for fulfilling SPEN’s full-refocusing condition. An additional delay (Td+) is used if the length of the gradient shape is superior to Ta/2.

1. Installation

**I.1 Requirements**

The SPEN method runs on Bruker Paravision 6.0x installed on Linux CentOS 5 or 7.

**I.2 Installation**

1) This method is based on the SPEN sequence and reconstruction developed by Prof. Lucio Frydman’s group. Before using it, you need to download and install the classical (not with multidimensional diffusion) SPEN method and reconstruction available at this address: <http://www.weizmann.ac.il/chemphys/Frydman_group/software>

We recommended you to test the classical SPEN method (my SPEN180) and reconstruction before starting the multidimensional diffusion.

2) Import and install the Paravision 6 source method: mySPEN180DWwave \_6.0.1.PvUserSrcMethod with: Files/Import/Source method

3) This method rquired gradient shapes, which need to be updated each time you change the diffusion encoding time. This operation is perform with the Matlab code: CreatePV6DiffusionShapesLooped. If you have matlab on your acquisition station you just need to run it with the correct diffusion time (tau line 21) and check the path of the resulting file line 16 which should be something like : /opt/PV6.0.1/prog/curdir/USRNAME/ParaVision/exp/lists/gp/ (USRNAME should be you user name).

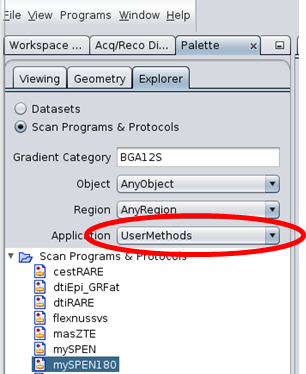
If you do not have Matlab on your acquisition station, you need to create the shape on another computer and copy them in the aforementioned path each time you want to modify the diffusion time.

4) To have automatic and optimized diffusion direction you need to copy the folder repulsion\_xyz to /opt/PV6.0.1/prog/curdir/USRNAME/ParaVision/exp/lists/. This will provide automatic directions if your diffusion direction number is comprised between 10 and 128.

**The multidimensional diffusion with SPEN acquistion and reconstruction is now operational on your scanner!**

5) The processing of the multidimensional diffusion data, which will give you the different Diffusion tensor Distribution parameters maps, is perform afterward with Matlab and can be download here: https://github.com/daniel-topgaard/md-dmri

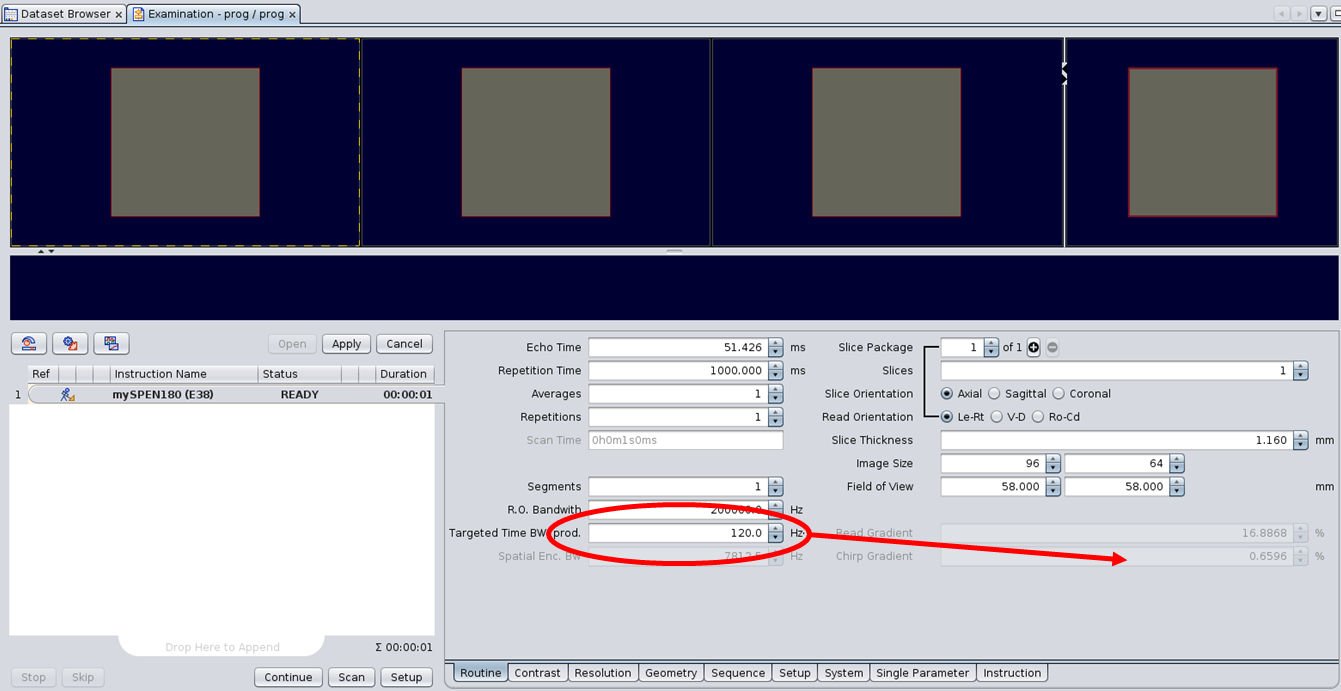
**I.3 First use**

* The sequence mySPEN180 and mySPEN180DWwave are

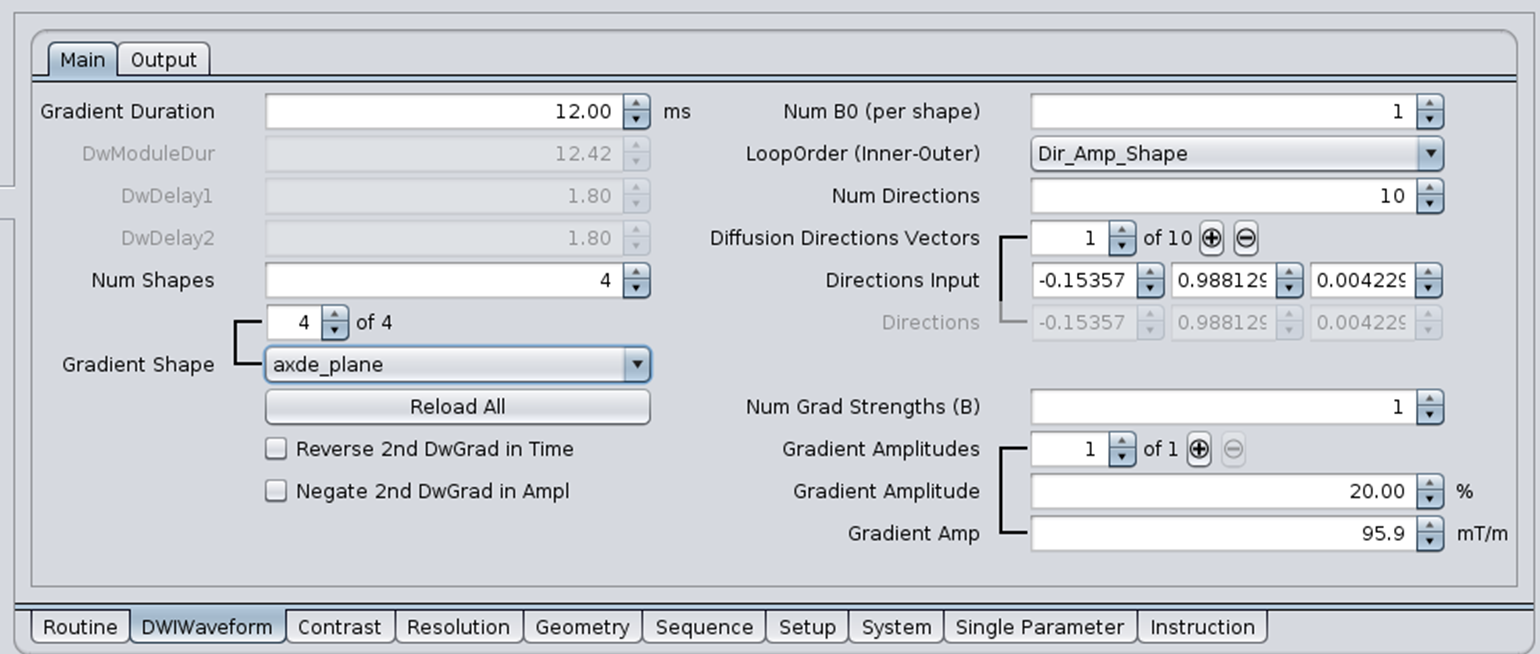
accessible under “UserMethods” in the palette after been

installed in the Workspace Explorer

* Both sequence exhibit the same classical parameters (echo time, repetition time, 3D…) as any other Bruker pulse sequence. The only specific parameter is the “Targeted Time BW prod” which allows the user to control the Chirp gradient strength. The chirp gradient duration (controlling the chirp bandwidth) is automatically set to half of the acquisition duration to be in the fully T2\* refocused condition.



* The multidimensional diffusion experiment require the use of 4 diffusion shapes named: stick, plane sphere and cigar. We also recommend to use multiple directions and multiple b-values.
* Each time you modify the Gradient duration you need to re-compute the shapes on Matlab.

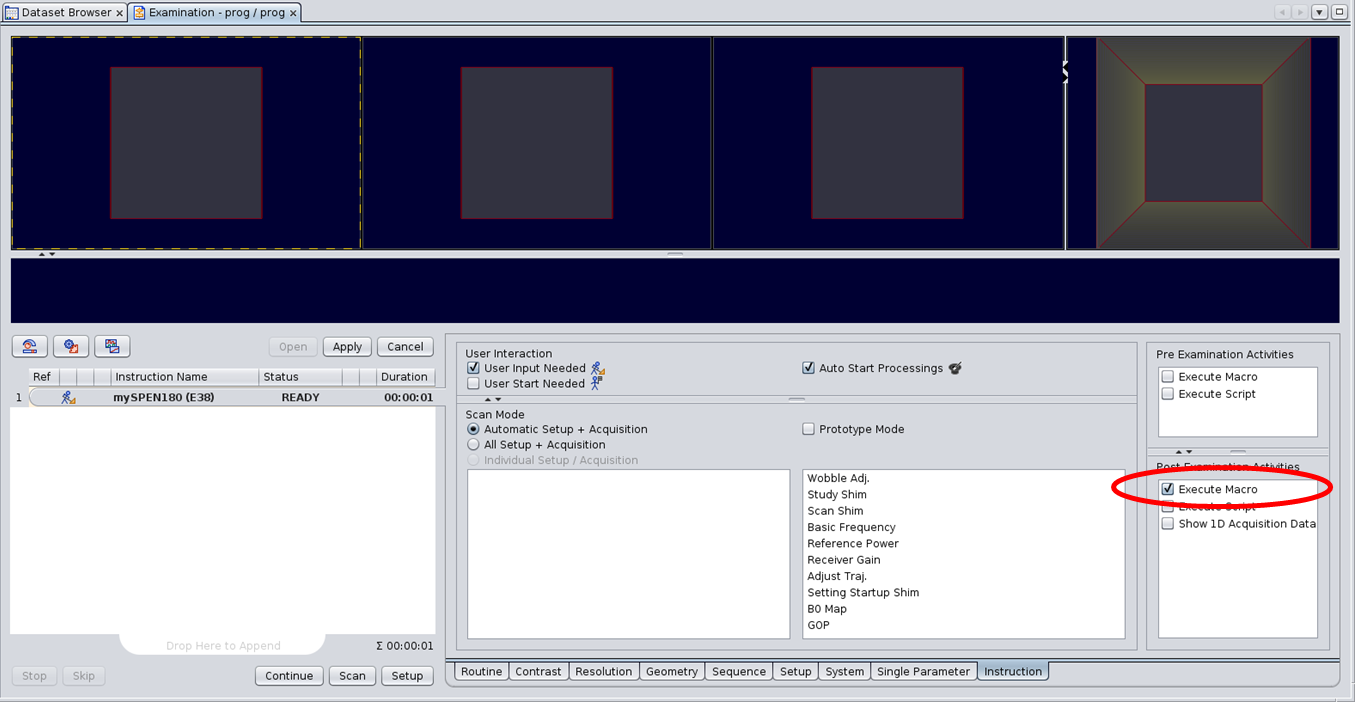


* To perform the reconstruction, you must call the macro “LaunchSPENprocess”

This call can be done automatically after the acquisition by adding a macro instruction in the "instruction/Execute Macro/USER/launchSPENprocess". The macro “LaunchSPENprocess” will be available under your user name. At the end of the acquisition, you should see the message "Executing post acquisition process".

Wait for the message to disappear and look at your first SPEN image!!!!

If you prefer to perform the reconstruction later, you can always call the macro from the EXPNO folder of the SPEN acquisition.



.