



FNNDSC
Fetal-Neonatal Neuroimaging
Developmental Science Center



**Boston
Children's
Hospital**



**HARVARD
MEDICAL SCHOOL**



DWI adults pipeline

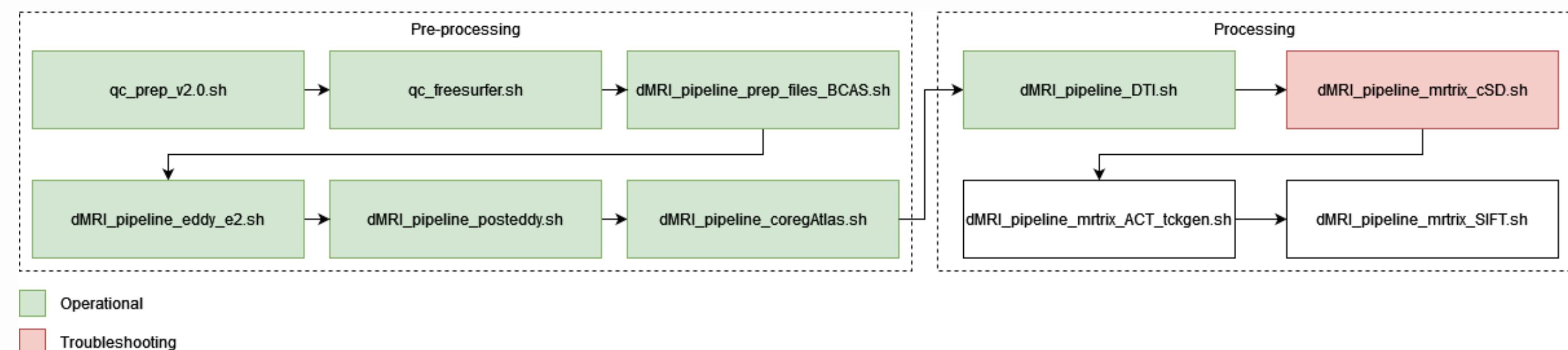
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Chung's pipeline overview



FreeSurfer



Private repository for documentation

Own structure for processing:

```
dMRI
--- util
----- info
----- scripts
--- subjects
----- ID
----- MRN
----- Study
----- COMPILED_RAW
----- FreeSurfer
----- Diffusion
```

 dMRI_BCH Private

Unwatch 1 ▾ Fork 0 ▾ Star 0 ▾

main ▾ 1 branch 0 tags Go to file Add file ▾ Code ▾

 mltCandela Update README.md c16516d 2 days ago 4 commits

 README.md Update README.md 2 days ago

 README.md

dMRI BCH ↗

Important paths ↗

- DATA /neuro/users/chris/PACS/data
- BCAS /neuro/labs/grantlab/research/BCAS
- SCRIPTS /neuro/labs/grantlab/research/QC_center/QC_scripts
- Environment /neuro/users/alejandra.perezyanez/anaconda3/envs/dMRI_env

About

Fetal dMRI at Boston Children's Hospital

Readme

Activity

0 stars

1 watching

0 forks

Releases

No releases published

Create a new release

Packages

No packages published

Publish your first package

Anaconda installation

01. Anaconda installation

```
[alejandra.perezyanez@hanyang:x86_64-Linux]~$>bash /neuro/labs/grantlab/research/MRI_processing/sungmi  
n.you/conda_env/conda_base/Anaconda3-2022.10-Linux-x86_64.sh  
  
Welcome to Anaconda3 2022.10  
  
In order to continue the installation process, please review the license  
agreement.  
Please, press ENTER to continue  
>>>
```

```
Anaconda3 will now be installed into this location:  
/neuro/users/alejandra.perezyanez/anaconda3
```

- Press ENTER to confirm the location
- Press CTRL-C to abort the installation
- Or specify a different location below

```
installation finished.

WARNING:
You currently have a PYTHONPATH environment variable set. This may cause
unexpected behavior when running the Python interpreter in Anaconda3.
For best results, please verify that your PYTHONPATH only points to
directories of packages that are compatible with the Python interpreter
in Anaconda3: /neuro/users/alejandra.perezyanez/anaconda3
Do you wish the installer to initialize Anaconda3
by running conda init? [yes|no]
[no] >>> yes
modified   /neuro/users/alejandra.perezyanez/anaconda3/condabin/conda
modified   /neuro/users/alejandra.perezyanez/anaconda3/bin/conda
modified   /neuro/users/alejandra.perezyanez/anaconda3/bin/conda-env
no change  /neuro/users/alejandra.perezyanez/anaconda3/bin/activate
no change  /neuro/users/alejandra.perezyanez/anaconda3/bin/deactivate
no change  /neuro/users/alejandra.perezyanez/anaconda3/etc/profile.d/conda.sh
no change  /neuro/users/alejandra.perezyanez/anaconda3/etc/fish/conf.d/conda.fish
no change  /neuro/users/alejandra.perezyanez/anaconda3/shell/condabin/Conda.psm1
no change  /neuro/users/alejandra.perezyanez/anaconda3/shell/condabin/conda-hook.ps1
no change  /neuro/users/alejandra.perezyanez/anaconda3/lib/python3.9/site-packages/xontrib/conda.xsh
no change  /neuro/users/alejandra.perezyanez/anaconda3/etc/profile.d/conda.csh
modified   /neuro/users/alejandra.perezyanez/.bashrc

==> For changes to take effect, close and re-open your current shell. <==

If you'd prefer that conda's base environment not be activated on startup,
set the auto_activate_base parameter to false:

conda config --set auto_activate_base false

Thank you for installing Anaconda3!
```

```
[alejandra.perezyanez@hanyang:x86_64-Linux]...yanez/anaconda3$source ~/.bashrc
(base) [alejandra.perezyanez@hanyang:x86_64-Linux]...yanez/anaconda3$conda
usage: conda [-h] [-V] command ...

conda is a tool for managing and deploying applications, environments and packages.

Options:
positional arguments:
  command
    clean      Remove unused packages and caches.
    compare   Compare packages between conda environments.
    config    Modify configuration values in .condarc. This is modeled after the git config
              command. Writes to the user .condarc file
              (/neuro/users/alejandra.perezyanez/.condarc) by default. Use the --show-sources
              flag to display all identified configuration locations on your computer.
    create     Create a new conda environment from a list of specified packages.
    info       Display information about current conda install.
    init       Initialize conda for shell interaction.
    install   Installs a list of packages into a specified conda environment.
    list      List installed packages in a conda environment.
    package   Low-level conda package utility. (EXPERIMENTAL)
    remove   Remove a list of packages from a specified conda environment.
    rename   Renames an existing environment.
    run      Run an executable in a conda environment.
    search   Search for packages and display associated information. The input is a MatchSpec, a
              query language for conda packages. See examples below.
    uninstall Alias for conda remove.
    update   Updates conda packages to the latest compatible version.
    upgrade  Alias for conda update.
    notices  Retrieves latest channel notifications.

optional arguments:
  -h, --help      Show this help message and exit.
  -V, --version   Show the conda version number and exit.

conda commands available from other packages:
  build
  content-trust
  convert
  debug
  develop
  env
  index
  inspect
  metapackage
  pack
  render
```

<https://docs.anaconda.com/anaconda/install/linux/>

Environment set up

Environment activation

```
./neuro/users/mri.team/packages/env_MRI_team;
```

```
[alejandra.perezyanez@hanyang:x86_64-Linux]~$>. ./neuro/users/mri.team/packages/env_MRI_team;

Host type is x86_64-Linux
Ubuntu 20.04
----- freesurfer-linux-ubuntu20_x86_64-7.3.2-20220804-6354275 -----
Setting up environment for FreeSurfer/FS-FAST (and FSL)
FREESURFER_HOME    /neuro/users/mri.team/packages/freesurfer/freesurfer_7_ubuntu20/
FSFAST_HOME        /neuro/users/mri.team/packages/freesurfer/freesurfer_7_ubuntu20//fsfast
FSF_OUTPUT_FORMAT  nii.gz
SUBJECTS_DIR       /neuro/users/alejandra.perezyanez
MNI_DIR            /neuro/users/mri.team/packages/freesurfer/freesurfer_7_ubuntu20//mni
FSL_DIR             /neuro/arch/x86_64-Linux/packages/fsl/6.0
```

FSL & Freesurfer environment

Environment setup

Environment creation

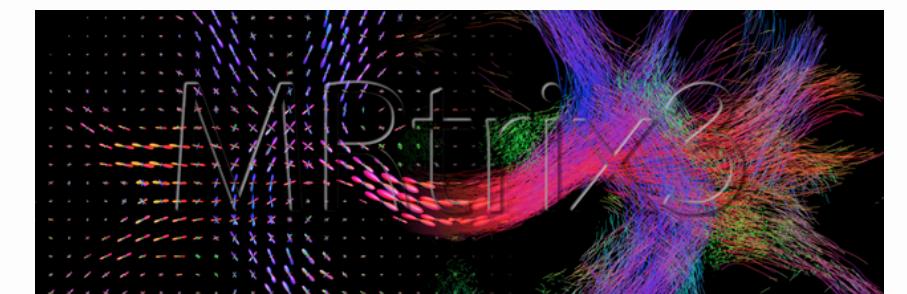
```
(base) [alejandra.perezyanez@hanyang:x86_64-Linux]...yanez/anaconda3$>conda create -n dMRI_env python=3
Collecting package metadata (current_repodata.json): done
Solving environment: done
```

Environment activation

```
[alejandra.perezyanez@hanyang:x86_64-Linux]...ra.perez/DWI_Ai$>conda activate dMRI_env
(dMRI_env) [alejandra.perezyanez@hanyang:x86_64-Linux]...ra.perez/DWI_Ai$>. /neuro/users/mri.team/packages/env_MRI_team;
Host type is x86_64-Linux
Ubuntu 20.04
----- freesurfer-linux-ubuntu20_x86_64-7.3.2-20220804-6354275 -----
Setting up environment for FreeSurfer/FS-FAST (and FSL)
FREESURFER_HOME    /neuro/users/mri.team/packages/freesurfer/freesurfer_7_ubuntu20/
FSFAST_HOME        /neuro/users/mri.team/packages/freesurfer/freesurfer_7_ubuntu20//fsfast
FSF_OUTPUT_FORMAT nii.gz
SUBJECTS_DIR       /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai
MNI_DIR            /neuro/users/mri.team/packages/freesurfer/freesurfer_7_ubuntu20//mni
FSL_DIR             /neuro/arch/x86_64-Linux/packages/fsl/6.0
```

MRtrix installation

```
(dMRI_env) [alejandra.perezyanez@hanyang:x86_64-Linux]...yanez/anaconda3$>conda install -c mrtrix3 mrtrix3  
Collecting package metadata (current_repodata.json): done  
Solving environment: done
```



Expected outcomes

DIFFUSION MODELING &
TRACKING

PREPROCESSING SCRIPTS

```
010888/
COMPILED_RAW/
dparameters.ini*  FreeSurferColorLUT.txt*  MASTER_diffusion.bval*
fs_a2009s.txt    fs_default.txt  mparameters.ini*
scripts/
```

```
Diffusion/  Freesurfer/
```

```
Atlases/  DTI/  MRtrix/  Preproc_files/  Transforms/
Etc/
```

```
010888_aveb0_brain.nii.gz      010888_aveb0.mif      010888_aveb0_to_JHU-ICBM-T2-2mm.log
010888_DWI_QCd.nii.gz  010888_T1W_to_b0.nii.gz  bvec_files/  FAST/
010888_aveb0_brain_to_JHU-ICBM-T2-2mm.log  010888_aveb0.nii.gz  010888_DWI_QCd.mif*
010888_T1W_to_b0.mif  010888_unbiased_bet_brain_mask.nii.gz*  Eddy/  PreEddy/
```

1

qc_prep_v2.0.sh

Creates COMPILED_RAW folder by compiling DICOMS

```
(dMRI_env) [alejandra.perezyanez@hanyang:x86_64-Linux]...ndra.perez/dMRI$>paso1
=====
Reading in /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/dMRI/util/info/BCAS_sequences_v2.0.ini...
=====
T1W *mocoMEMPRAGE_RMS*
DWI *SMSDTI_3[S|s]hells_bmax3000*
DWI_AP *SMSDTI_AP*
DWI_PA *SMSDTI_PA*
fMRI *SMS3_rs-fMRI3mmIso*
fMRI_PA *SMS3_rs-fMRI3mmIso_PA*
T2W *3D_T2_SPACE*

=====
Creating subject folder and creating symbolic links in /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/dMRI/subjects/001/dcm...
=====
00005-mocoMEMPRAGE_RMS-6acf2f9...
00006-3D_T2_SPACE-51df5d2...
00007-SMSDTI_3shells_bmax3000-6f5a317...
00013-SMSDTI_AP-c080dd7...
00014-SMSDTI_PA-4204a94...
00015-SMSDTI_AP-34a0b3b...
00016-SMSDTI_PA-b5e1f61...
00017-SMS3_rs-fMRI3mmIso-73c7960...
00018-SMS3_rs-fMRI3mmIso_PA-7277d57...
```

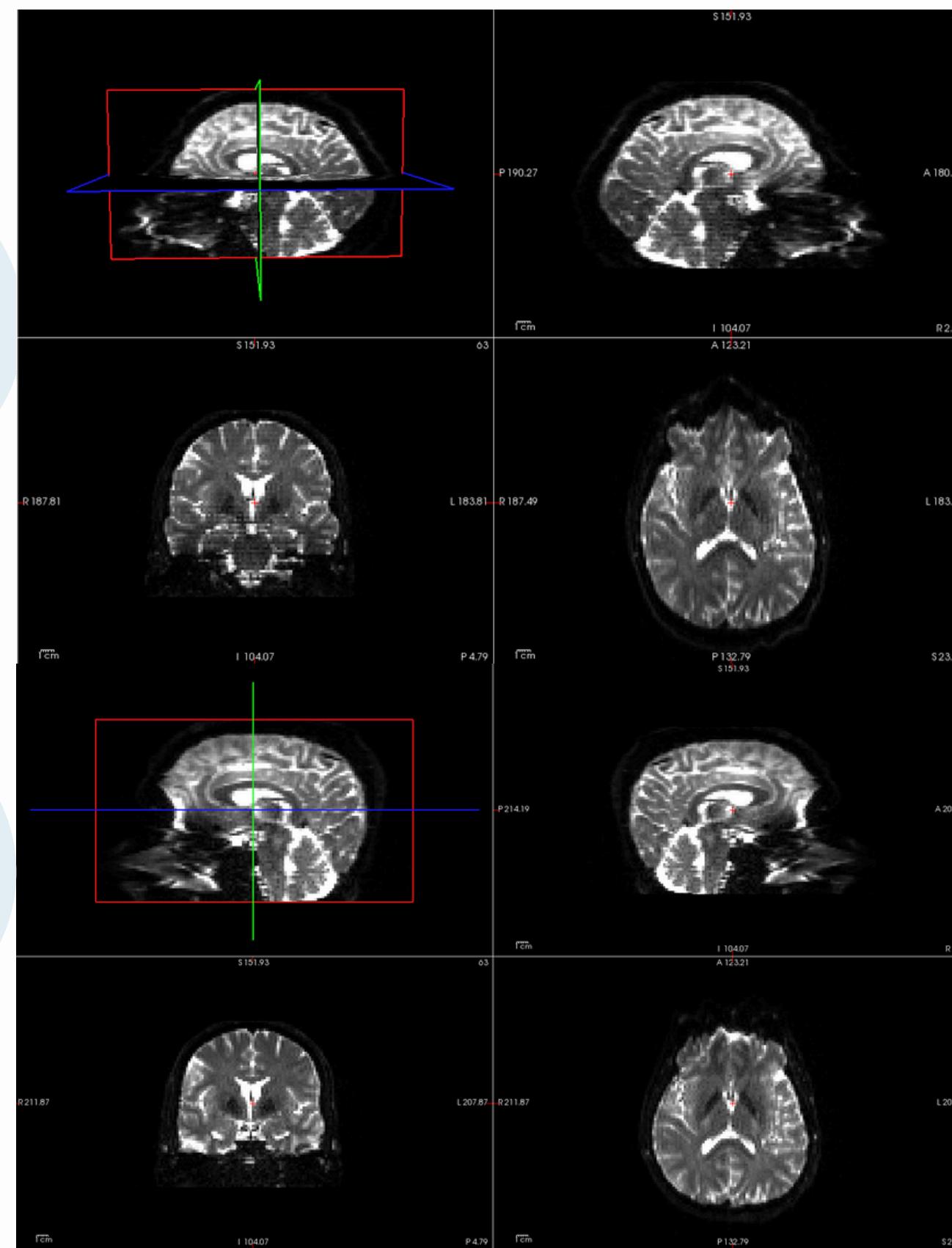
Outcome

```
(dMRI_env) [hanyang:x86_64-Linux-MRI-team]...RI/subjects/001$>ls 5349811-KOESTER_STEVE-19920921/MR-EI_Neuro-25518237-20190621/COMPILED_RAW/
001_RAW_DWI_AP_0.nii.gz 001_RAW_DWI.nii.gz 001_RAW_DWI_PA_1.nii.gz 001_RAW_fMRI_1.nii.gz 001_RAW_T1W.nii.gz
001_RAW_DWI_AP_1.nii.gz 001_RAW_DWI_PA_0.nii.gz 001_RAW_fMRI_0.nii.gz 001_RAW_fMRI_PA.nii.gz 001_RAW_T2W.nii.gz
```

Outcome

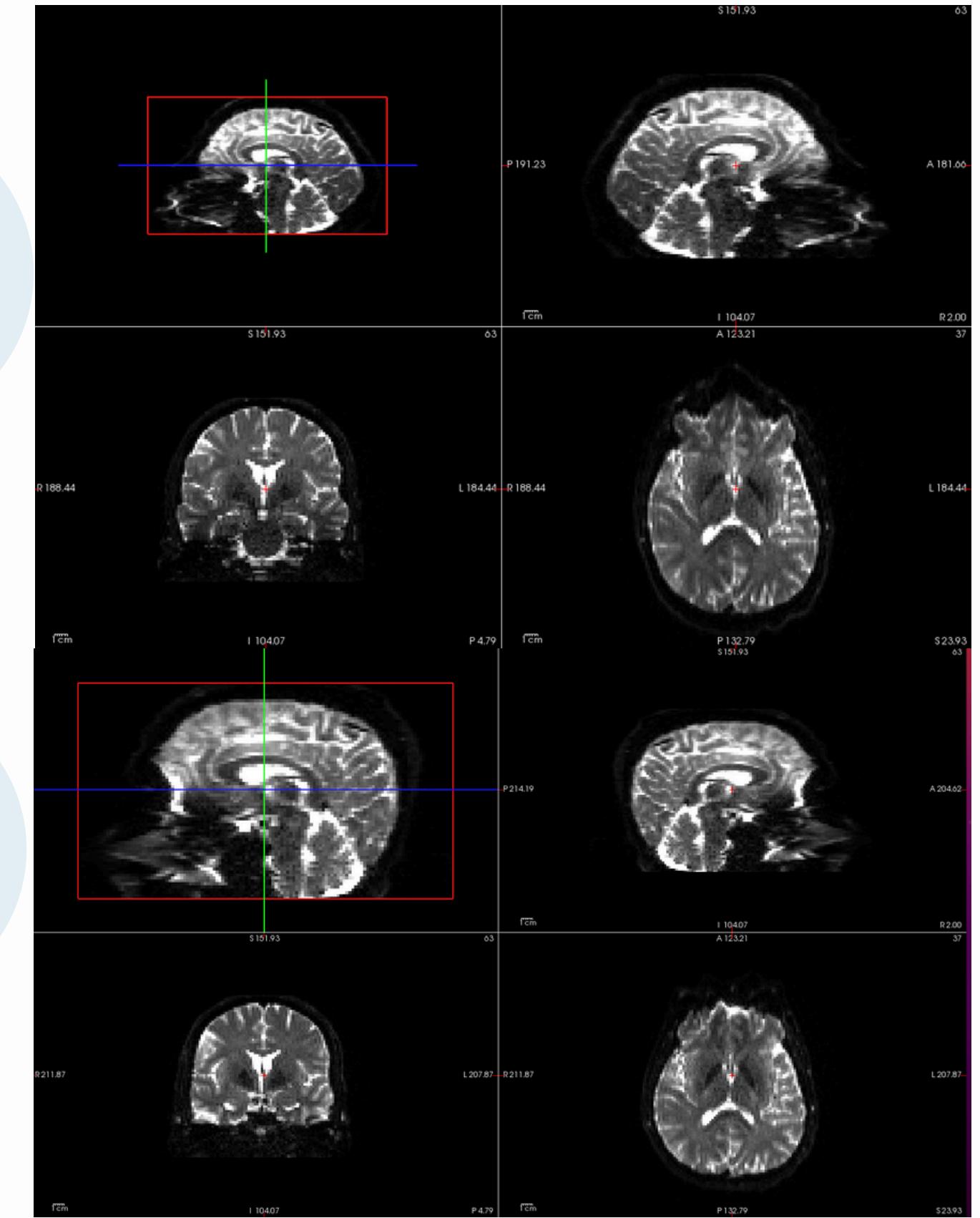
AP 0

- Antero posterior acquisition



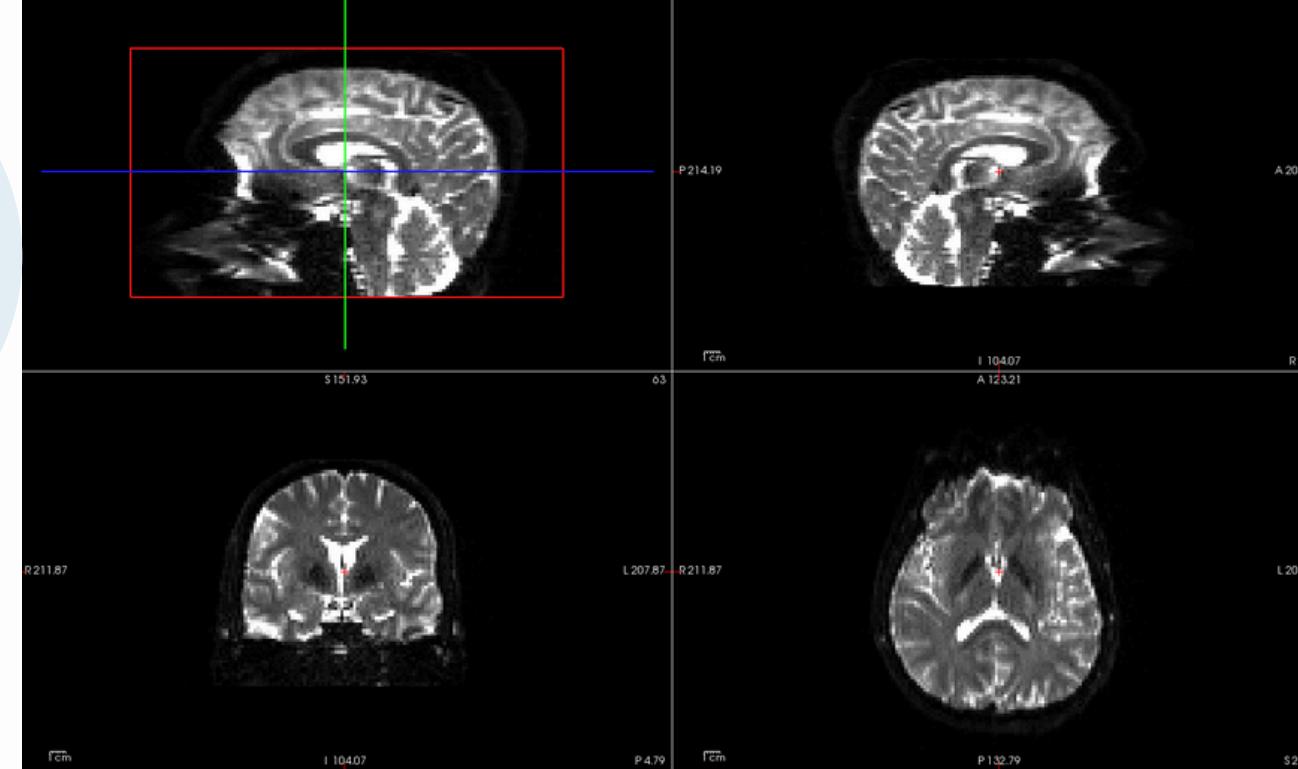
AP 1

- Antero posterior acquisition



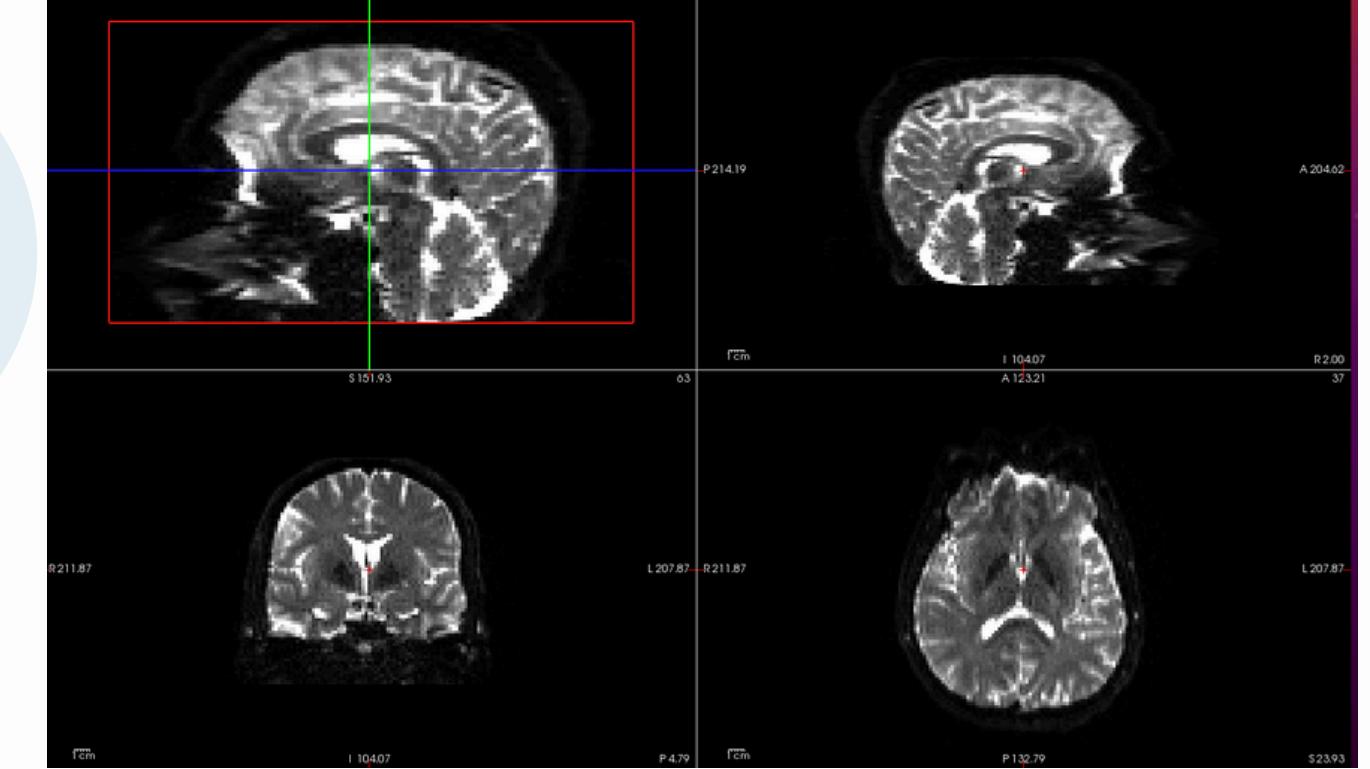
PA 0

- Posterior anterior acquisition



PA 1

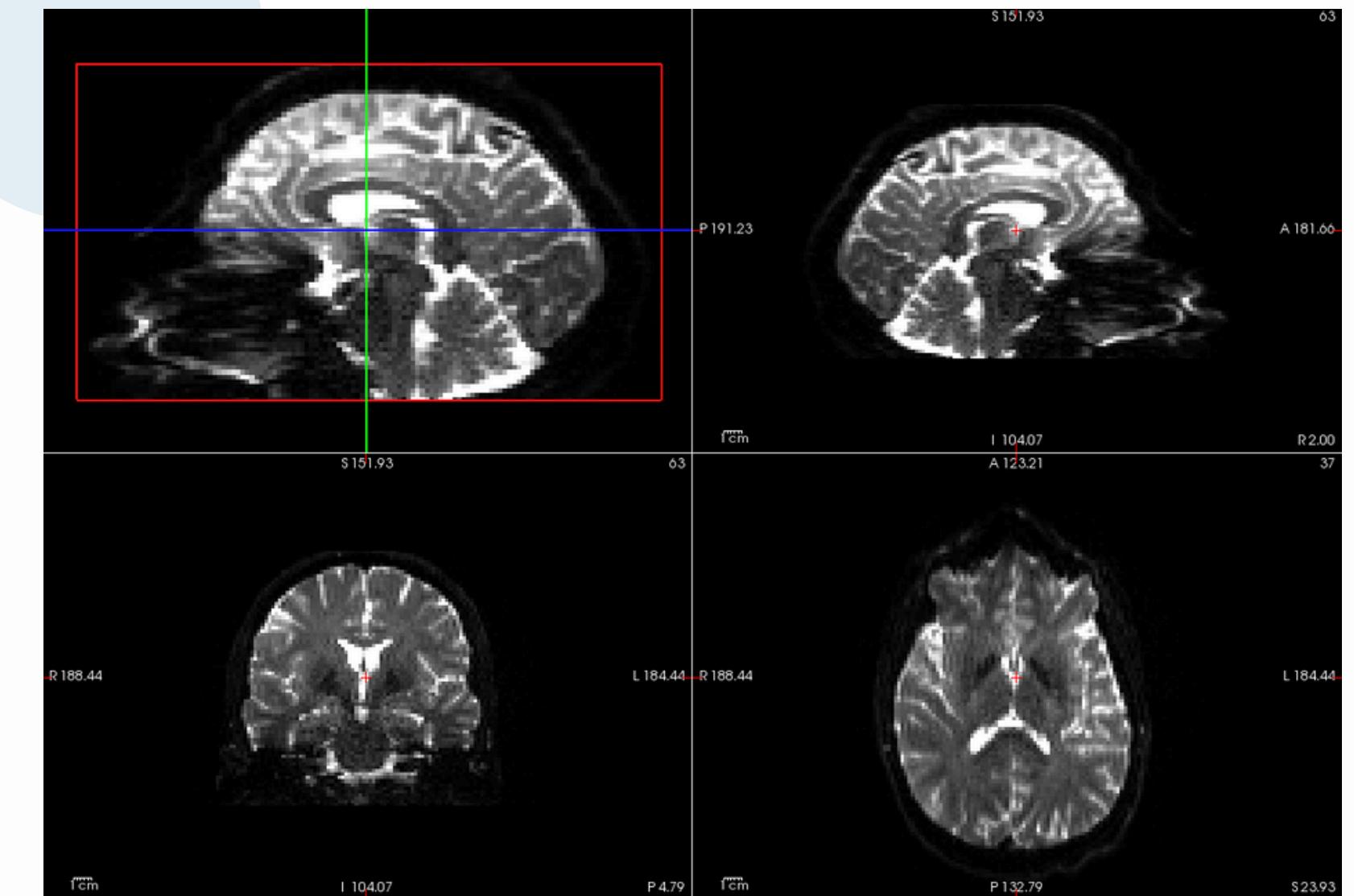
- Posterior anterior acquisition



*AP0 and AP1 represent different encoding directions. Having 2 images in the same encoding direction allows to correct inhomogenities

Outcome

T1 W



2

qc_freesurfer.sh

Generates the reconstruction of T1 images

```
[hanyang:x86_64-Linux-MRI-team]...ra.perez/DWI_Ai$>pwd  
/neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai  
[hanyang:x86_64-Linux-MRI-team]...ra.perez/DWI_Ai$>/neuro/labs/grantlab/research/MRI_processing/alejan  
dra.perez/DWI_Ai/scripts/qc_freesurfer.sh /neuro/labs/grantlab/research/MRI_processing/alejandra.perez  
/DWI_Ai/COMPILED_RAW/010888_RAW_T1W.nii.gz /neuro/labs/grantlab/research/MRI_processing/alejandra.pere  
z/DWI_Ai/010888_copy
```

```
Started at Fri Oct 13 15:12:03 EDT 2023  
Ended   at Fri Oct 13 22:53:27 EDT 2023  
#@### recon-all-run-time-hours 7.690  
recon-all -s Freesurfer finished without error at Fri Oct 13 22:53:28 EDT 2023  
done
```

```
[hanyang:x86_64-Linux-MRI-team]...z/DWI_Ai/010888$>ls  
Freesurfer/  fsaverage@
```

```
[hanyang:x86_64-Linux-MRI-team]...z/DWI_Ai/010888$>ls Freesurfer/  
label/  mri/  scripts/  stats/  surf/  tmp/  touch/  trash/
```

Freesurfer/tmp:

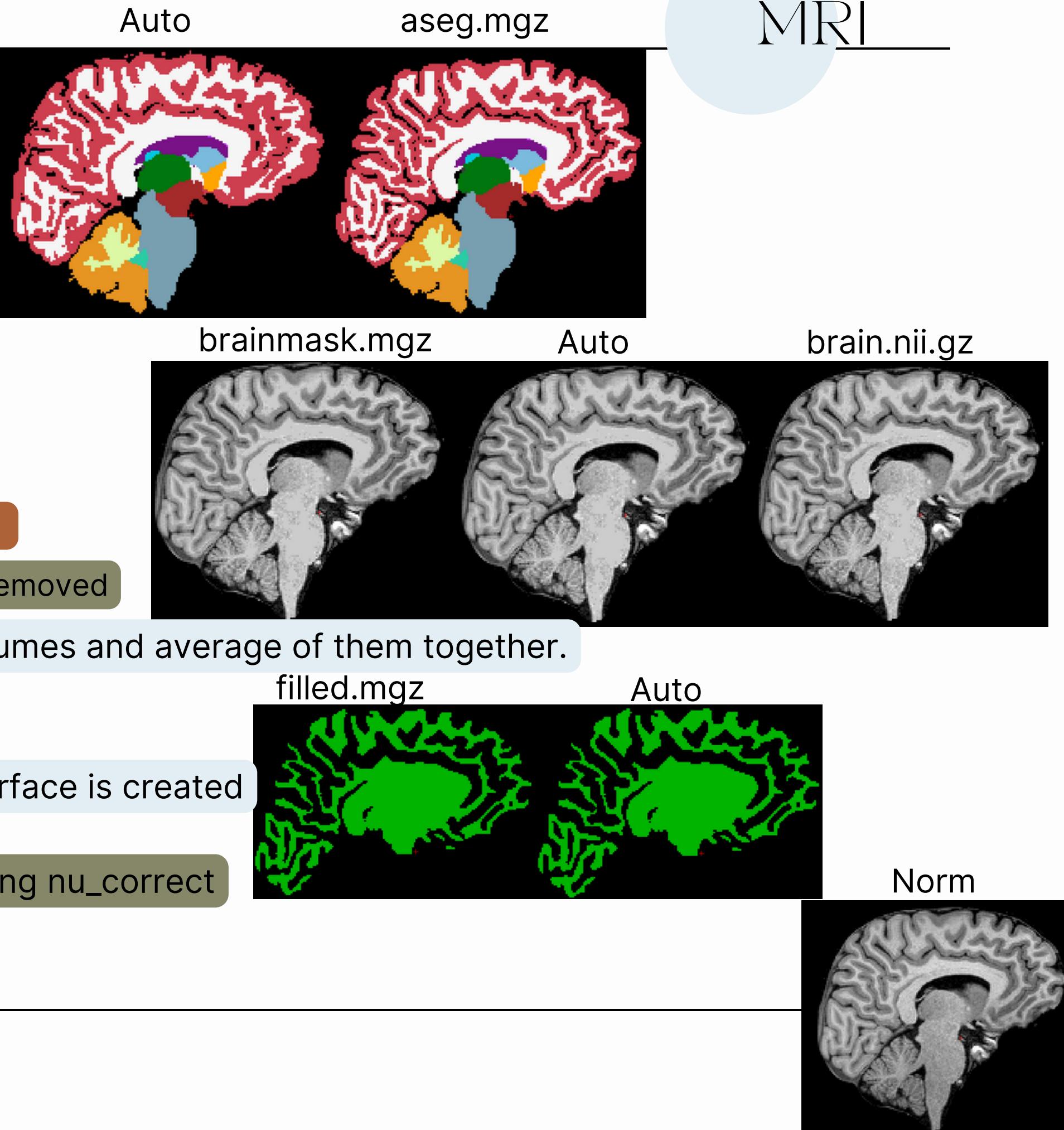
Freesurfer/touch:	lh.cortex+hipamyg.touch	lh.white.touch	rh.pial.touch
	apseas2aseg.touch	nu.touch	rh.qsphere.touch
	asegmerge.touch	relabelhypos.touch	rh.smoothwm1.touch
	ca_label.touch	lh.curvstats.touch	rh.aparc2.touch
	ca_normalize.touch	lh.inflate1.touch	rh.smoothwm2.touch
	ca_register.touch	lh.inflate2.touch	rh.aparcstats2.touch
	conform.touch	lh.inflate.H.K.touch	rh.aparcstats3.touch
	cortical_ribbon.touch	lh.jacobian_white.touch	rh.sphreg.touch
	em_register.touch	lh.pctsurfcon.touch	rh.aparcstats.touch
	fill.touch	lh.pial.touch	rh.tessellate.touch
	inorm1.touch	lh.qsphere.touch	rh.topofix.touch
	inorm2.touch	lh.smoothwm1.touch	rh.white.H.K.touch
	lh.aparc2.touch	lh.smoothwm2.touch	rh.white.preaparc.touch
	lh.aparcstats2.touch	lh.sphmorph.touch	rh.white.touch
	lh.aparcstats3.touch	lh.spfreg.touch	segstats.touch
	lh.aparcstats.touch	lh.tessellate.touch	skull.lta.touch
	lh.aparc.touch	lh.topofix.touch	skull_strip.touch
	lh.autodet.gw.stats.touch	lh.white.H.K.touch	talairach.touch
	lh.avgcurv.touch	lh.white.preaparc.touch	wmaparc.stats.touch
		lh.white.touch	wmsegment.touch

Freesurfer/trash:

labels subcortical structures

Freesurfer/label:		
aparc.annot.a2009s.ctab	lh.FG1.mpm.vpnL.label	rh.BA45_exvivo.thresh.label
aparc.annot.ctab	lh.FG2.mpm.vpnL.label	rh.BA4a_exvivo.label
aparc.annot.DKTatlas.ctab	lh.FG3.mpm.vpnL.label	rh.BA4a_exvivo.thresh.label
BA_exvivo.ctab	lh.FG4.mpm.vpnL.label	rh.BA4p_exvivo.label
BA_exvivo.thresh.ctab	lh.h0c1.mpm.vpnL.label	rh.BA4p_exvivo.thresh.label
lh.aparc.a2009s.annot	lh.h0c2.mpm.vpnL.label	rh.BA6_exvivo.label
lh.aparc.annot	lh.h0c3v.mpm.vpnL.label	rh.BA6_exvivo.thresh.label
lh.aparc.DKTatlas.annot	lh.h0c4v.mpm.vpnL.label	rh.BA_exvivo.annot
lh.BA1_exvivo.label	lh.mpm.vpnL.annot	rh.BA_exvivo.thresh.annot
lh.BA1_exvivo.thresh.label	lh.MT_exvivo.label	rh.cortex+hipamyg.label
lh.BA2_exvivo.label	lh.MT_exvivo.thresh.label	rh.cortex.label
lh.BA2_exvivo.thresh.label	lh.nofix.cortex.label	rh.entorhinal_exvivo.label
lh.BA3a_exvivo.label	lh.perirhinal_exvivo.label	rh.entorhinal_exvivo.thresh.label
lh.BA3a_exvivo.thresh.label	lh.perirhinal_exvivo.thresh.label	rh.FG1.mpm.vpnL.label
lh.BA3b_exvivo.label	lh.V1_exvivo.label	rh.FG2.mpm.vpnL.label
lh.BA3b_exvivo.thresh.label	lh.V1_exvivo.thresh.label	rh.FG3.mpm.vpnL.label
lh.BA44_exvivo.label	lh.V2_exvivo.label	rh.FG4.mpm.vpnL.label
lh.BA44_exvivo.thresh.label	lh.V2_exvivo.thresh.label	rh.h0c1.mpm.vpnL.label
lh.BA45_exvivo.label	rh.aparc.a2009s.annot	rh.h0c2.mpm.vpnL.label
lh.BA45_exvivo.thresh.label	rh.aparc.annot	rh.h0c3v.mpm.vpnL.label
lh.BA4a_exvivo.label	rh.aparc.DKTatlas.annot	rh.h0c4v.mpm.vpnL.label
lh.BA4a_exvivo.thresh.label	rh.BA1_exvivo.label	rh.mpm.vpnL.annot
lh.BA4p_exvivo.label	rh.BA1_exvivo.thresh.label	rh.MT_exvivo.label
lh.BA4p_exvivo.thresh.label	rh.BA2_exvivo.label	rh.MT_exvivo.thresh.label
lh.BA6_exvivo.label	rh.BA2_exvivo.thresh.label	rh.nofix.cortex.label
lh.BA6_exvivo.thresh.label	rh.BA3a_exvivo.label	rh.perirhinal_exvivo.label
lh.BA_exvivo.annot	rh.BA3a_exvivo.thresh.label	rh.perirhinal_exvivo.thresh.label
lh.BA_exvivo.thresh.annot	rh.BA3b_exvivo.label	rh.V1_exvivo.label
lh.cortex+hipamyg.label	rh.BA3b_exvivo.thresh.label	rh.V1_exvivo.thresh.label
lh.cortex.label	rh.BA44_exvivo.label	rh.V2_exvivo.label
lh.entorhinal_exvivo.label	rh.BA44_exvivo.thresh.label	rh.V2_exvivo.thresh.label
lh.entorhinal_exvivo.thresh.label	rh.BA45_exvivo.label	

antsdn.brain.mgz
 aparc.a2009s+aseg.mgz
 aparc+aseg.mgz
 aparc.DKTatlas+aseg.mgz
 aseg.auto.mgz labels subcortical structures
 aseg.auto_noCCseg.label_intensities.txt
 aseg.auto_noCCseg.mgz
 aseg.mgz labels subcortical structures
 aseg.presurf.h ypos.mgz
 aseg.presurf.mgz
 brain.finalsurfs.mgz
 brainmask.auto.mgz The removal of the skull from t1.mgz
 brainmask.mgz Major intensity normalization after skull was removed
 brain.mgz
 brain.nii.gz Correction for small motions between volumes and average of them together.
 ctrl_pts.mgz
 filled.auto.mgz
 filled.mgz Creates subcortical mass from which orig surface is created
 lh.ribbon.mgz
 mri_nu_correct.mni.log
 mri_nu_correct.mni.log.bak Intensity corrections using nu_correct
 norm.mgz Normalization based on GCA model
 nu.mgz



BAK, ORIG & TRANSFORMS

```
bak/  
cc_up.lta  
talairach.auto.xfm  
talairach.auto.xfm.lta  
talairach_avi.log  
talairach_avi_QA.log  
talairach.lta      align nu.mgz to default GCA atlas  
talairach.m3z    linear transformation to align with GCA atlas  
talairach_with_skull.lta  
talairach.xfm  
talairach.xfm.lta  
talsrcimg_to_711-2C_as_mni_average_305_t4_vox2vox.txt
```



orig/ Inputs for motion correction

orig.mgz
orig_nu.mgz
rawavg.mgz
rh.ribbon.mgz
ribbon.mgz
segment.dat
surface.defects.mgz

T1.mgz Intensity normalization of orig volume

talairach.label_intensities.txt

talairach.log

talairach_with_skull.log

transforms/

wm.asegedit.mgz

wm.mgz wm separation from everything else

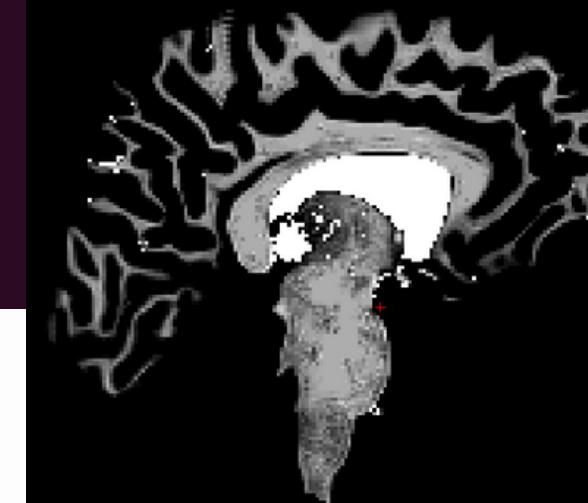
wmparc.mgz

WM.seg.mgz



affine transform from orig volume to the MNI305 atlas

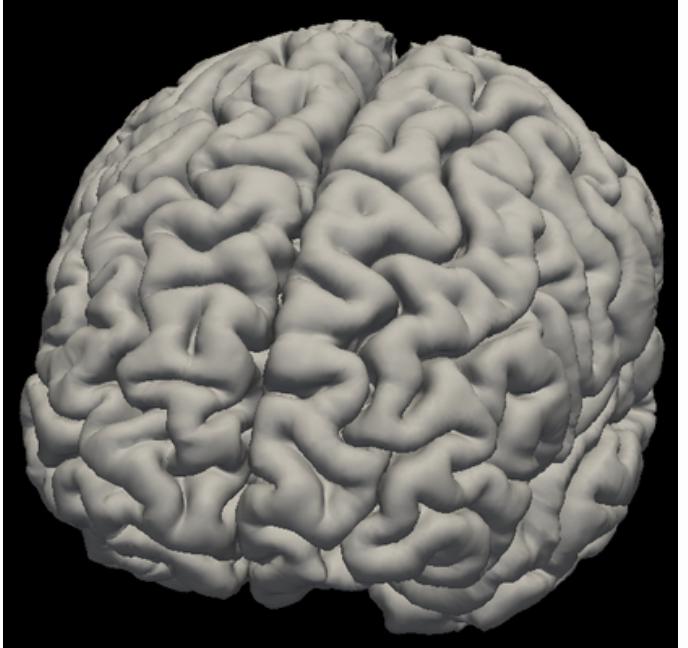
wm.mgz



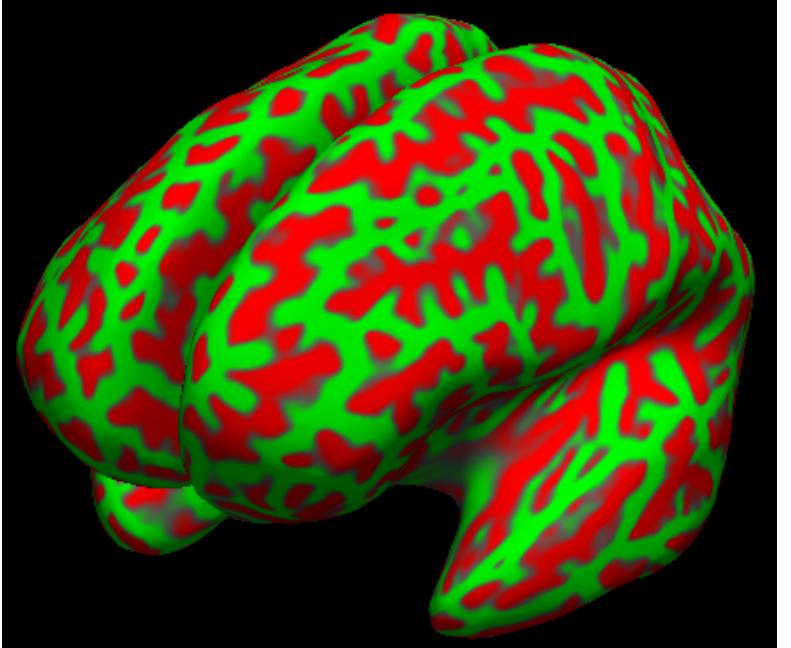
STATS & SURF

Freesurfer/scripts:	patchdir.txt defect2seg.log lastcall.build-stamp.txt	ponscc.cut.log pctsurfcon.log pctsurfcon.log.old	recon-all.cmd recon-all.done	recon-all.env recon-all.local-copy*	recon-all.log recon-all-status.log recon-config.yaml unknown-args.txt
Statistics on aseg.mgz					
parcellation statistics					
Freesurfer/stats:					
aseg.stats brainvol.stats lh.aparc.a2009s.stats lh.aparc.DKTatlas.stats lh.aparc.pial.stats	lh.aparc.stats lh.BA_exvivo.stats lh.BA_exvivo.thresh.stats lh.curv.stats lh.w-g.pct.stats	rh.aparc.a2009s.stats rh.aparc.DKTatlas.stats rh.aparc.pial.stats rh.aparc.stats rh.BA_exvivo.stats	rh.BA_exvivo.thresh.stats rh.curv.stats rh.w-g.pct.stats wmparc.stats		
Freesurfer/surf:					
autodet.gw.stats.lh.dat autodet.gw.stats.rh.dat lh.area lh.area.mid lh.area.pial lh.avg_curv lh.curv lh.curv.pial lh.defect_borders lh.defect_chull lh.defect_labels lh.defects.pointset lh.fsaverage.sphere.reg@ lh.inflated lh.inflated.H lh.inflated.K lh.inflated.nofix lh.jacobian_white lh.orig lh.orig.nofix lh.orig.premesh lh.pial@ lh.pial.T1	lh.qsphere.nofix lh.smoothwm lh.smoothwm.BE.crv lh.smoothwm.C.crv lh.smoothwm.FI.crv lh.smoothwm.H.crv lh.smoothwm.K1.crv lh.smoothwm.K2.crv lh.smoothwm.K.crv lh.smoothwm.nofix lh.smoothwm.S.crv lh.sphere lh.sphere.reg lh.sulc lh.thickness lh.volume lh.w-g.pct.mgh lh.white lh.white.H@ lh.white.K@ lh.white.preaparc lh.white.preaparc.H lh.white.preaparc.K	localizes topological defects(from inflation) created with inflation rh.area rh.area.mid rh.area.pial rh.avg_ resamples avg curvature from atlas to the subject's rh.curv created with inflation rh.curv.pial rh.defect_borders rh.defect_chull rh.defect_labels rh.defects.pointset rh.fsaverage.sphere.reg@ rh.inflated inflation that minimizes distortion rh.inflated.H rh.inflated.K rh.inflated.nofix rh.jacobian white rh.orig initial topology fixing (qsphere.nofix) rh.orig.nofix covers filled hemisphere with triangles rh.orig.premesh rh.pial@ rh.pial.T1 final surface rh.qsphere.nofix localizes topological defects(from inflation) rh.smoothwm adjustment after tessellation	created with inflation rh.area rh.area.mid rh.area.pial resamples avg curvature from atlas to the subject's created with inflation rh.curv rh.curv.pial rh.defect_borders rh.defect_chull rh.defect_labels rh.defects.pointset rh.fsaverage.sphere.reg@ inflation that minimizes distortion rh.inflated.H rh.inflated.K rh.inflated.nofix rh.jacobian white initial topology fixing (qsphere.nofix) covers filled hemisphere with triangles rh.orig.premesh rh.pial@ final surface localizes topological defects(from inflation)	rh.smoothwm.BE.crv rh.smoothwm.C.crv rh.smoothwm.FI.crv rh.smoothwm.H.crv rh.smoothwm.K1.crv rh.smoothwm.K2.crv rh.smoothwm.K.crv rh.smoothwm.nofix rh.smoothwm.S.crv rh.sphere rh.sphere.reg registers orig surf to atlas through .sphere rh.sulc created with inflation folding patterns rh.thickness rh.volume rh.w-g.pct.mgh rh.white final surface rh.white.H@ rh.white.K@ rh.white.preaparc rh.white.preaparc.H rh.white.preaparc.K	

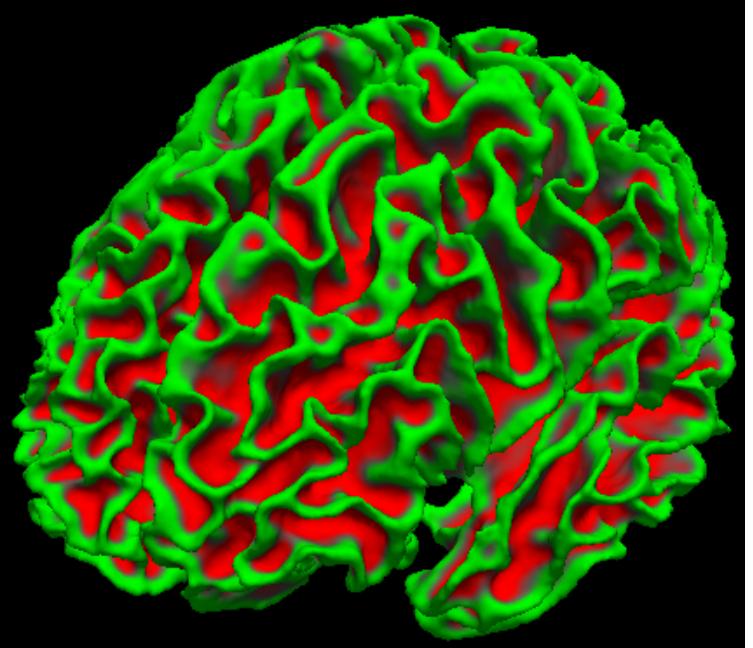
lh/rh.pial.T1



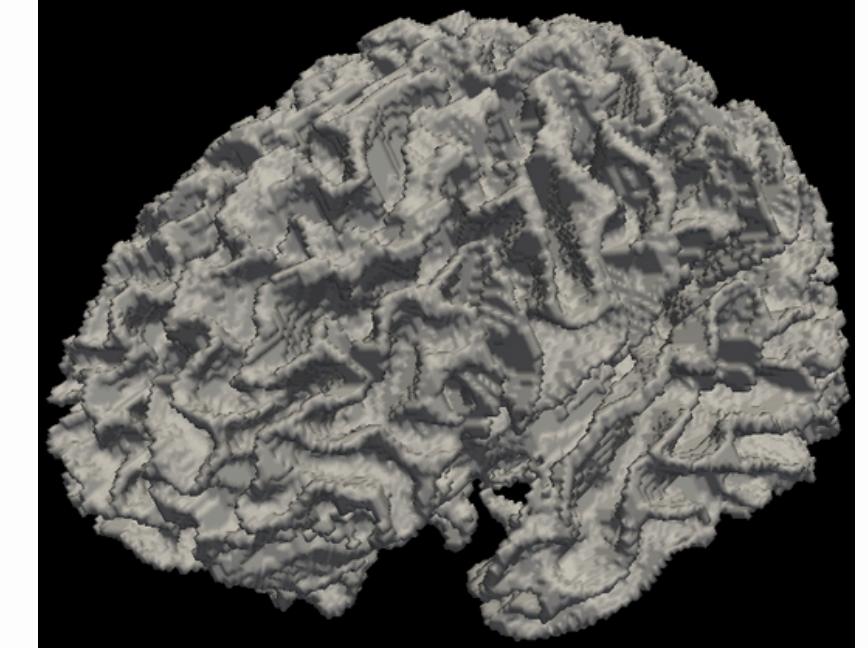
lh/rh inflated



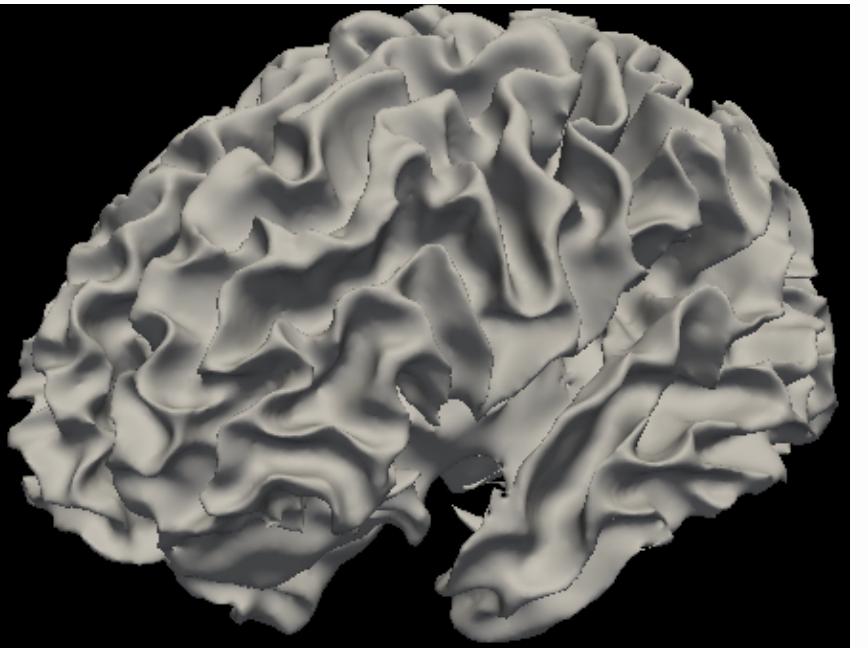
lh/rh orig



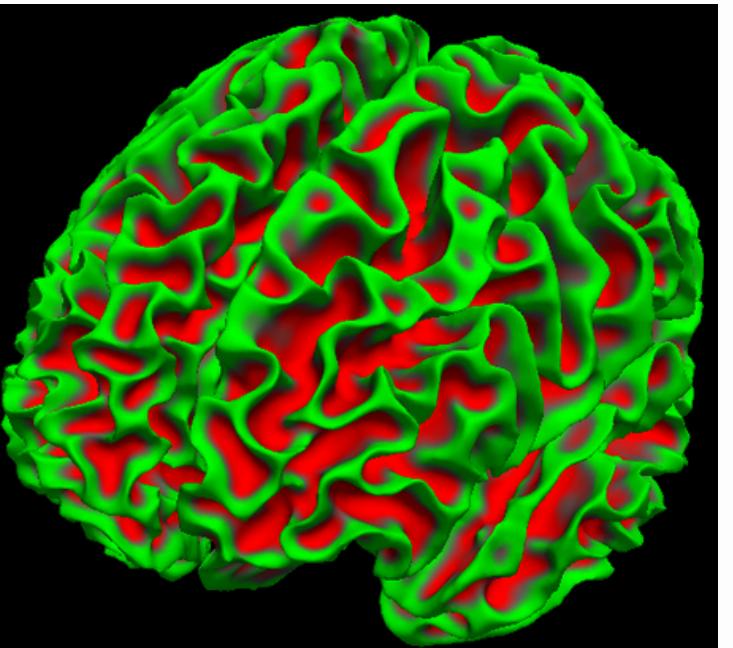
lh/rh orig.nofix



lh/rh smoothwm.nofix



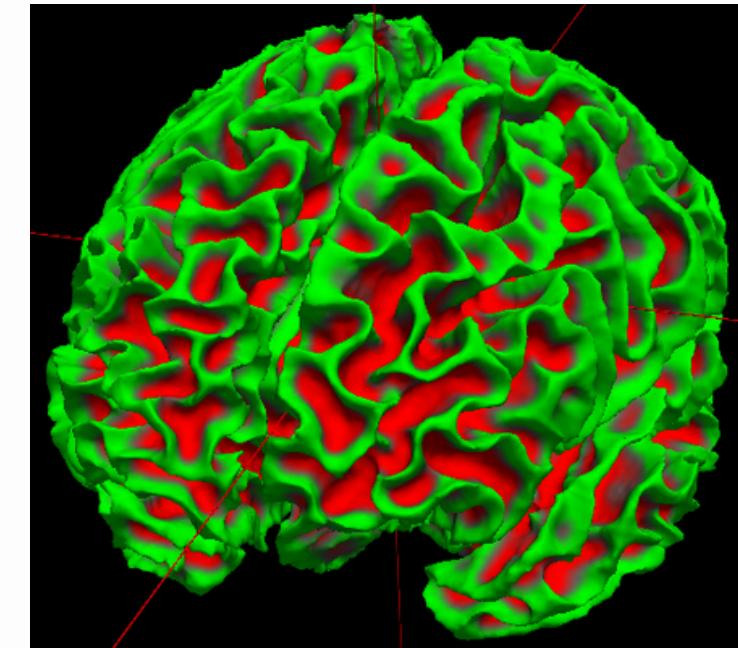
lh/rh smoothwm



lh/rh qsphere.nofix

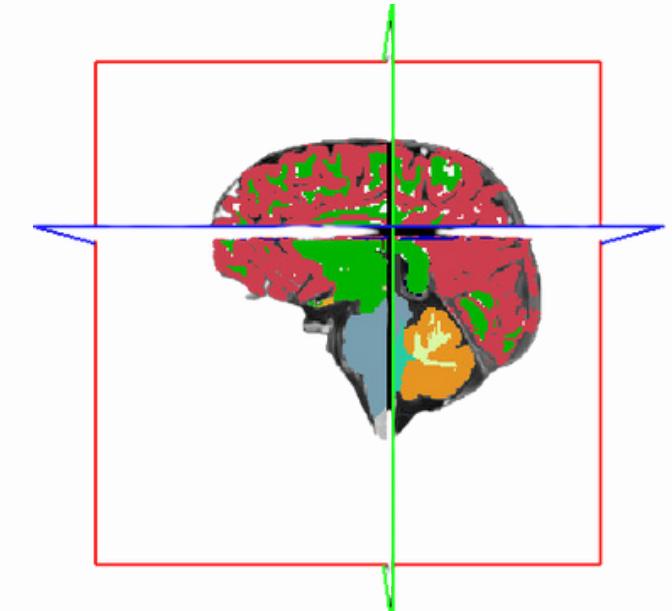


lh/rh white



LABEL

Define ROI's and labels them. In other words, they assign identifiers to specific ROI's .



MRI

Files .mgz. Contain parcellation files according to certain atlases

STATS

usually contain stats related to ROI's , quality control metrics and atlas-based metrics.

TMP

Define ROI's and labels them. In other words, they assign identifiers to specific ROI's .

TOUCH

.Touch files. These usually contain timestamps, meaning that they have information about the file, eg. modifications, access and creation dates.

3

dMRI_pipeline_prep_files_BCAS.sh

```
[alejandra.perezyanz@hanyang:x86_64-Linux]...z/DWI_Ai/010888$>ls  
dcm/ Freesurfer/ fsaverage@  
[alejandra.perezyanz@hanyang:x86_64-Linux]...z/DWI_Ai/010888$>ls dcm  
3D_T2_SPACE-3D_T2_SPACE-288084/  
epi_navSet-epi_navSet-288112/  
epi_navSet-mocoMEMPRAGE-288111/  
FUJI_Basic_Text_SR_for_HL7_Radiological_Report-NoProtocolName-288119/  
localizer-localizer-288114/  
mocoMEMPRAGE_RMS_all-mocoMEMPRAGE-288083/  
MoCoSeries-PCASL-288101/  
mprage_axial-mocoMEMPRAGE-288094/  
mprage_coronal-mocoMEMPRAGE-288107/  
_MPR_Range_-mocoMEMPRAGE-288102/  
PCASL-PCASL-288110/  
PCASL_RelCBF-PCASL-288118/  
SMS3_rs_fMRI3mmIso_PA-SMS3_rs_fMRI3mmIso_PA-288100/  
SMS3_rs_fMRI3mmIso-SMS3_rs_fMRI3mmIso-288109/  
SMSDTI_3Shells_bmax3000_ADC-SMSDTI_3Shells_bmax3000-288117/  
SMSDTI_3Shells_bmax3000_ColFA-SMSDTI_3Shells_bmax3000-288097/  
SMSDTI_3Shells_bmax3000_EXP-SMSDTI_3Shells_bmax3000-288095/  
SMSDTI_3Shells_bmax3000_FA-SMSDTI_3Shells_bmax3000-288098/  
SMSDTI_3Shells_bmax3000-SMSDTI_3Shells_bmax3000-288113/  
SMSDTI_3Shells_bmax3000_TRACEW-SMSDTI_3Shells_bmax3000-288093/  
SMSDTI_AP-SMSDTI_AP-288115/  
SMSDTI_AP-SMSDTI_AP-288116/  
SMSDTI_PA-SMSDTI_PA-288099/  
SMSDTI_PA-SMSDTI_PA-288108/  
spiralCSI_2cc3d_TE30-spiralCSI_2cc3d_TE30-288086/  
spiralCSI_2cc3d_TE30_waterRef-spiralCSI_2cc3d_TE30_waterRef-288085/  
T2Space_axial-3D_T2_SPACE-288096/  
T2Space_coronal-3D_T2_SPACE-288092/
```

A dcm dir has to be obtained (from Chris)

```
[hanyang:x86_64-Linux-MRI-team]...ra.perez/DWI_Ai$>/neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/scripts/dMRI_pipeline_prep_files_BCAS.sh /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/010888 SMSDTI_3Shells_bmax3000-SMSDTI_3Shells_bmax3000-288113 /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/COMPILED_RAW /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/dparameters.ini]
```

Outcomes

- Diffusion directory is generated
- Preproc_files created
- PreEddy created

```
/neuro/labs/grantlab/research/MRI_processing/alejandra.perez/  
DWI_Ai/010888/Diffusion/Preproc_files/PreEddy
```

```
PreEddy  
└── 010888_diffusion.bval  
└── 010888_diffusion.bvec  
└── 010888_diffusion_params2.json  
└── 010888_diffusion_params.json  
└── 010888_DWI_degibbs.mif  
└── 010888_DWI_degibbs.nii.gz  
└── 010888_DWI_denoised.mif  
└── 010888_DWI_denoised.nii.gz  
└── 010888_DWI_noise.mif  
└── 010888_DWI_resid_degibbs.mif  
└── 010888_DWI_resid_degibbs.nii.gz  
└── 010888_DWI_resid_denoise.mif  
└── 010888_DWI_resid_denoise.nii.gz  
└── 010888_DWI_rms_resid_denoise.mif  
└── 010888_grad.b  
└── 010888_RAW_DWI_shells.mif  
└── 010888_RAW_DWI_shells.nii.gz
```

bval

Correspond to each b-value. It describes the strength and timing of the magnetic field gradients.

Higher bval's allow to look at more specific points of diffusion

$$b = \gamma^2 G^2 \delta^2 (\Delta - \delta/3)$$

γ = gyromagnetic ratio (constant fixed for specific nucleus)

G = Magnitude of diffusion gradient

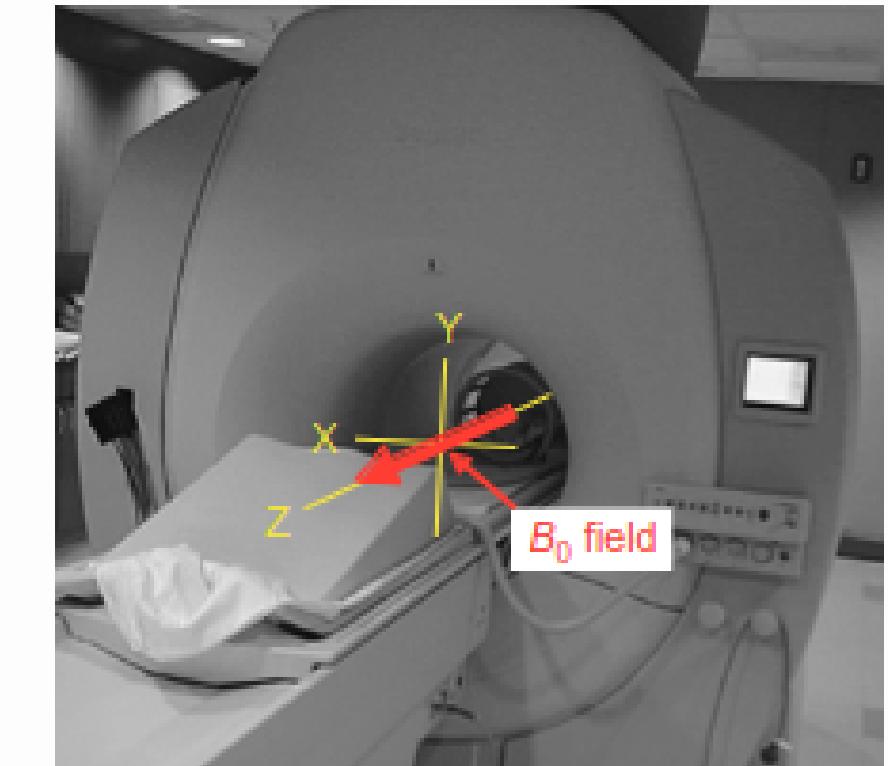
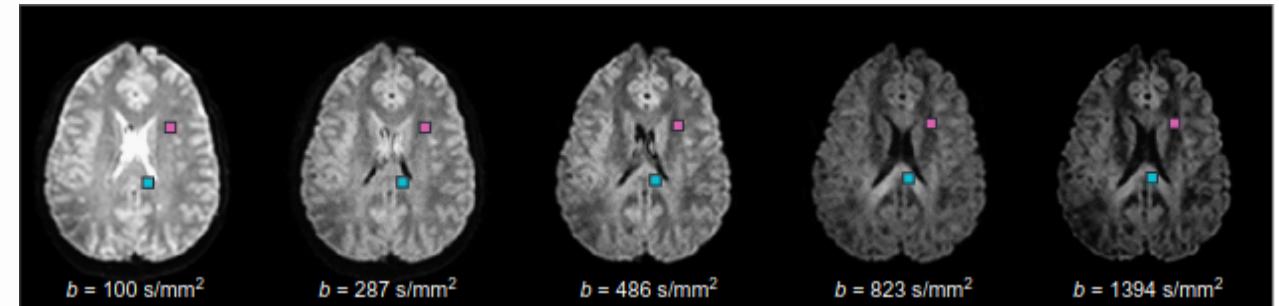
δ = Duration of diffusion gradient

Δ = Time between gradients

	X	y	Z
0	0.00000000	0.00000000	0.00000000
0	0.00000000	0.00000000	0.00000000
1000	0.22414696	0.00771935	-0.97452474
2000	0.22373158	0.00533175	-0.97463626
3000	0.22367804	0.00461380	-0.97465205
1000	-0.28247747	-0.26701617	-0.92136252
2000	-0.28204784	-0.26388955	-0.92239439
3000	-0.28159189	-0.26245961	-0.92294139
1000	0.04256013	0.49341363	-0.86875308
2000	0.04240611	0.48996186	-0.87071186
3000	0.04243857	0.48857254	-0.87149054
1000	0.34619635	-0.45927274	-0.81805664
2000	0.34530643	-0.45614067	-0.82018232
3000	0.34508964	-0.45468420	-0.82108188
1000	-0.62737000	0.11935289	-0.76952064
2000	-0.62576532	0.11665753	-0.77123863
3000	-0.62520754	0.11537169	-0.77188379
1000	0.58445179	0.38000602	-0.71694613
2000	0.58338159	0.37686467	-0.71947128
3000	0.58305746	0.37547195	-0.72046149
1000	-0.19274837	-0.72184324	-0.66467327
2000	-0.19201702	-0.71923757	-0.66770262
0	0.00000000	0.00000000	0.00000000
3000	-0.19189526	-0.71796530	-0.66910553
1000	-0.36092758	0.70192856	-0.61402577
2000	-0.36030594	0.69933504	-0.61734116
3000	-0.36019546	0.69812161	-0.61877757
1000	0.77224547	-0.29038730	-0.56507713
2000	0.77090567	-0.28749165	-0.56837755
3000	0.77051276	-0.28620490	-0.56955844
1000	-0.78955489	-0.33420438	-0.51469469
2000	-0.78867579	-0.33130124	-0.51790923
3000	-0.78837591	-0.33021107	-0.51906097
1000	0.37312788	0.80430174	-0.46246520
2000	0.37292176	0.80210555	-0.46642914
3000	0.37310433	0.80112243	-0.46797022
1000	0.27093950	-0.86987823	-0.41219398
2000	0.27103376	-0.86809951	-0.41586527
3000	0.27087134	-0.86728436	-0.41766796
1000	-0.80272508	0.47320786	-0.36291420
2000	-0.80249411	0.47078031	-0.36656398
3000	-0.80241030	0.46955985	-0.36830860
0	0.92546636	0.21253216	-0.31359532
2000	0.00000000	0.00000000	0.00000000
3000	0.92494613	0.20955169	-0.31711623
1000	0.92473465	0.20805390	-0.31871530
2000	-0.55163336	-0.79203242	-0.26150656
3000	-0.55217570	-0.79023057	-0.26577765
1000	-0.55213451	-0.78959131	-0.26775587
2000	-0.12528960	0.96927953	-0.21165928
3000	-0.12528363	0.96839237	-0.21568549
1000	-0.12513831	0.96798623	-0.21758473
2000	0.75052577	-0.64057136	-0.16241725
3000	0.75121278	-0.63880259	-0.16616382

bvec

Correspond to the b-vectors. They represent the directions in which the DWI were taken.



grad b

Compilation of bval and
bvecs

```
(dMRI_env) [hanyang:x86_64-Linux-MRI-team]...c_files/PreEddy$>cat 010888_grad.b
0 0 0
0 0 0
0.2241470 0.0077193 -0.9745247 1000
0.2237316 0.0053317 -0.9746363 2000
0.2236780 0.0046138 -0.9746520 3000
-0.2824775 -0.2670162 -0.9213625 1000
-0.2820478 -0.2638895 -0.9223944 2000
-0.2815919 -0.2624596 -0.9229414 3000
0.0425601 0.4934136 -0.8687531 1000
0.0424061 0.4899619 -0.8707119 2000
0.0424386 0.4885725 -0.8714905 3000
0.3461963 -0.4592727 -0.8180566 1000
0.3453064 -0.4561407 -0.8201823 2000
0.3450896 -0.4546842 -0.8210819 3000
-0.6273700 0.1193529 -0.7695206 1000
-0.6257653 0.1166575 -0.7712386 2000
-0.6252075 0.1153717 -0.7718838 3000
0.5844518 0.3800060 -0.7169461 1000
0.5833816 0.3768647 -0.7194713 2000
0.5830575 0.3754719 -0.7204615 3000
-0.1927484 -0.7218432 -0.6646733 1000
-0.1920170 -0.7192376 -0.6677026 2000
0 0 0
-0.1918953 -0.7179653 -0.6691055 3000
-0.3609276 0.7019286 -0.6140258 1000
-0.3603059 0.6993350 -0.6173412 2000
-0.3601955 0.6981216 -0.6187776 3000
0.7722455 -0.2903873 -0.5650771 1000
0.7709057 -0.2874916 -0.5683776 2000
0.7705128 -0.2862049 -0.5695584 3000
-0.7895549 -0.3342044 -0.5146947 1000
-0.7886758 -0.3313012 -0.5179092 2000
-0.7883759 -0.3302111 -0.5190610 3000
0.3731279 0.8043017 -0.4624652 1000
0.3729218 0.8021055 -0.4664291 2000
0.3731043 0.8011224 -0.4679702 3000
0.2709395 -0.8698782 -0.4121940 1000
0.2710338 -0.8680995 -0.4158653 2000
0.2708713 -0.8672844 -0.4176680 3000
-0.8027251 0.4732079 -0.3629142 1000
-0.8024941 0.4707803 -0.3665640 2000
-0.8024103 0.4695599 -0.3683086 3000
0.9254664 0.2125322 -0.3135953 1000
0 0 0
```

```
(base) [hanyang:x86_64-Linux-MRI-team]...c_files/PreEddy$>cat 010888_diffusion_params.json
{
    "Modality": "MR",
    "MagneticFieldStrength": 3,
    "ImagingFrequency": 123.222,
    "Manufacturer": "Siemens",
    "ManufacturersModelName": "Skyra",
    "InstitutionName": "BOSTON_CHILDRENS_HOSPITAL",
    "InstitutionalDepartmentName": "Department",
    "InstitutionAddress": "LONGWOOD_200_BOSTON_MA_US_02115",
    "DeviceSerialNumber": "45479",
    "StationName": "BINN7SKY",
    "BodyPartExamined": "BRAIN",
    "PatientPosition": "HFS",
    "ProcedureStepDescription": "MR_Experimental_Imaging_(EI)",
    "SoftwareVersions": "syngo_MR_E11",
    "MRAcquisitionType": "2D",
    "SeriesDescription": "SMSDTI_3shells_bmax3000",
    "ProtocolName": "SMSDTI_3shells_bmax3000",
    "ScanningSequence": "EP",
    "SequenceVariant": "SK_SP",
    "ScanOptions": "PFP_FS",
    "SequenceName": "ep_b0",
    "ImageType": ["ORIGINAL", "PRIMARY", "DIFFUSION", "NONE", "ND", "NORM", "MOSAIC"],
    "SeriesNumber": 10,
    "AcquisitionTime": "18:12:7.740000",
    "AcquisitionNumber": 1,
    "SliceThickness": 2,
    "SpacingBetweenSlices": 2,
    "SAR": 0.336914,
    "EchoTime": 0.114,
    "RepetitionTime": 5.7,
    "FlipAngle": 90,
    "PartialFourier": 0.75,
    "BaseResolution": 128,
    "ShimSetting": [
        -4692,
        -14887,
        -15137,
        542,
        613,
        -2091,
        302,
        192
    ],
    "TxRefAmp": 329.665,
    "PhaseResolution": 1,
    "ReceiveCoilName": "HeadNeck_64",
    "ReceiveCoilActiveElements": "HC3-7;NC1",
    "PulseSequenceDetails": "%CustomerSeq%_ep2d_diff_sms_abcd",
    "WipMemBlock": "be315d23-a942-4464-804c-0d6f44864f34",
    "RefLinesPE": 32,
    "ConsistencyInfo": "N4_VE11C_LATEST_20160120",
    "MultibandAccelerationFactor": 2,
    "PercentPhaseFOV": 100,
    "PercentSampling": 100,
    "EchoTrainLength": 48,
    "PhaseEncodingSteps": 96,
    "AcquisitionMatrixPE": 128,
    "ReconMatrixPE": 128,
    "BandwidthPerPixelPhaseEncode": 22.321,
    "ParallelReductionFactorInPlane": 2,
    "EffectiveEchoSpacing": 0.00035007,
    "DerivedVendorReportedEchoSpacing": 0.000700013,
    "TotalReadoutTime": 0.0444509,
    "PixelBandwidth": 1630,
    "DwellTime": 2.4e-06,
    "PhaseEncodingDirection": "j-",
    "TxRefAmp": 329.665
}
```

.json

Image acquisition data

```

    "DiffusionScheme": "Bipolar",
    "TxRefAmp": 329.665,
    "PhaseResolution": 1,
    "ReceiveCoilName": "HeadNeck_64",
    "ReceiveCoilActiveElements": "HC3-7;NC1",
    "PulseSequenceDetails": "%CustomerSeq%_ep2d_diff_sms_abcd",
    "WipMemBlock": "be315d23-a942-4464-804c-0d6f44864f34",
    "RefLinesPE": 32,
    "ConsistencyInfo": "N4_VE11C_LATEST_20160120",
    "MultibandAccelerationFactor": 2,
    "PercentPhaseFOV": 100,
    "PercentSampling": 100,
    "EchoTrainLength": 48,
    "PhaseEncodingSteps": 96,
    "AcquisitionMatrixPE": 128,
    "ReconMatrixPE": 128,
    "BandwidthPerPixelPhaseEncode": 22.321,
    "ParallelReductionFactorInPlane": 2,
    "EffectiveEchoSpacing": 0.00035007,
    "DerivedVendorReportedEchoSpacing": 0.000700013,
    "TotalReadoutTime": 0.0444509,
    "PixelBandwidth": 1630,
    "DwellTime": 2.4e-06,
    "PhaseEncodingDirection": "j-",
    "TxRefAmp": 329.665
}
```

```
"SliceTiming": [  
    2.7625,  
    0,  
    2.9175,  
    0.1525,  
    3.07,  
    0.3075,  
    3.2225,  
    0.46,  
    3.3775,  
    0.615,  
    3.53,  
    0.7675,  
    0.7675,  
    3.685,  
    0.92,  
    3.8375,  
    1.075,  
    3.99,  
    1.2275,  
    4.145,  
    1.3825,  
    4.2975,  
    1.535,  
    4.4525,  
    1.6875,  
    4.605,  
    1.8425,  
    4.76,  
    1.995,  
    4.9125,  
    2.15,  
    5.065,  
    2.3025,  
    5.22,  
    2.455,  
    5.3725,  
    2.61,  
    5.5275,  
    2.7625,  
    0,  
    2.9175,  
    0.1525,  
    3.07,  
    0.3075,  
    3.2225,  
    0.46,  
    3.3775,  
    0.615,  
    3.53,  
    0.7675,  
    3.685,  
    0.92,  
    3.8375,  
    1.075,  
    3.99,  
    1.2275,  
    4.145,  
    1.3825,  
    4.2975,  
    1.535,  
    4.4525,  
    1.6875,  
    4.605,  
    1.8425,  
    4.76,  
    1.995,  
    4.9125,  
    2.15,  
    5.065,  
    2.3025,  
    5.22,  
    2.455,  
    5.3725,  
    2.61,  
    5.5275  ],
```

```
"ImageOrientationPatientDICOM": [  
    1,  
    0,  
    0,  
    0,  
    1,  
    0      ],  
"InPlanePhaseEncodingDirectionDICOM": "COL",  
"ConversionSoftware": "dcm2niix",  
"ConversionSoftwareVersion": "v1.0.20200331"
```

Image orientation patient: composed by 2 vectors, which represent the columns and rows. They show the position of the image in relation to the patient.

1\0\0\0\1\0- transverse plane
1\0\0\0\0\1- coronal orientation
0\1\0\0\0\1-saggital orientation

RAW_DWI_shells

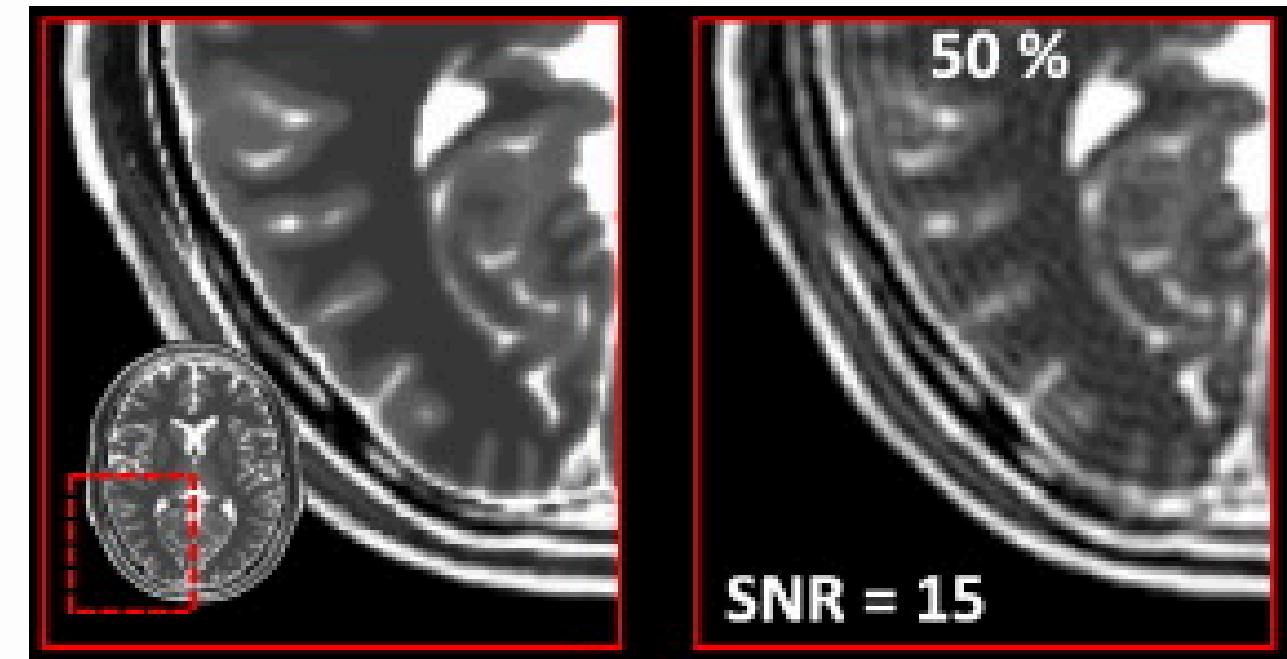
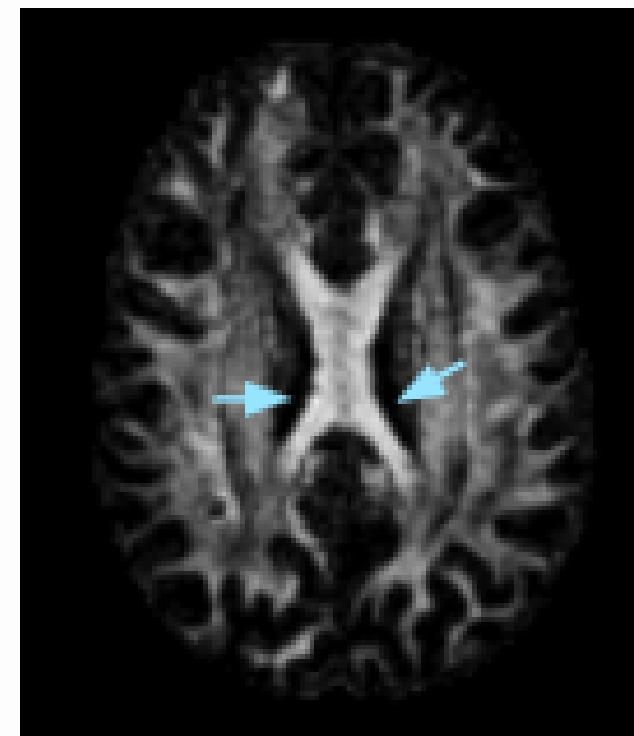
- shell: ranges or intervals of b values
- RAW_DWI_shells: images acquired during the chosen shells

denoise

- Aims to reduce unwanted noise while preserving the required information

degibbs

- Gibbs ringing is an artifact presented as waves in edges.
Degibbs works to eliminate that artifact.



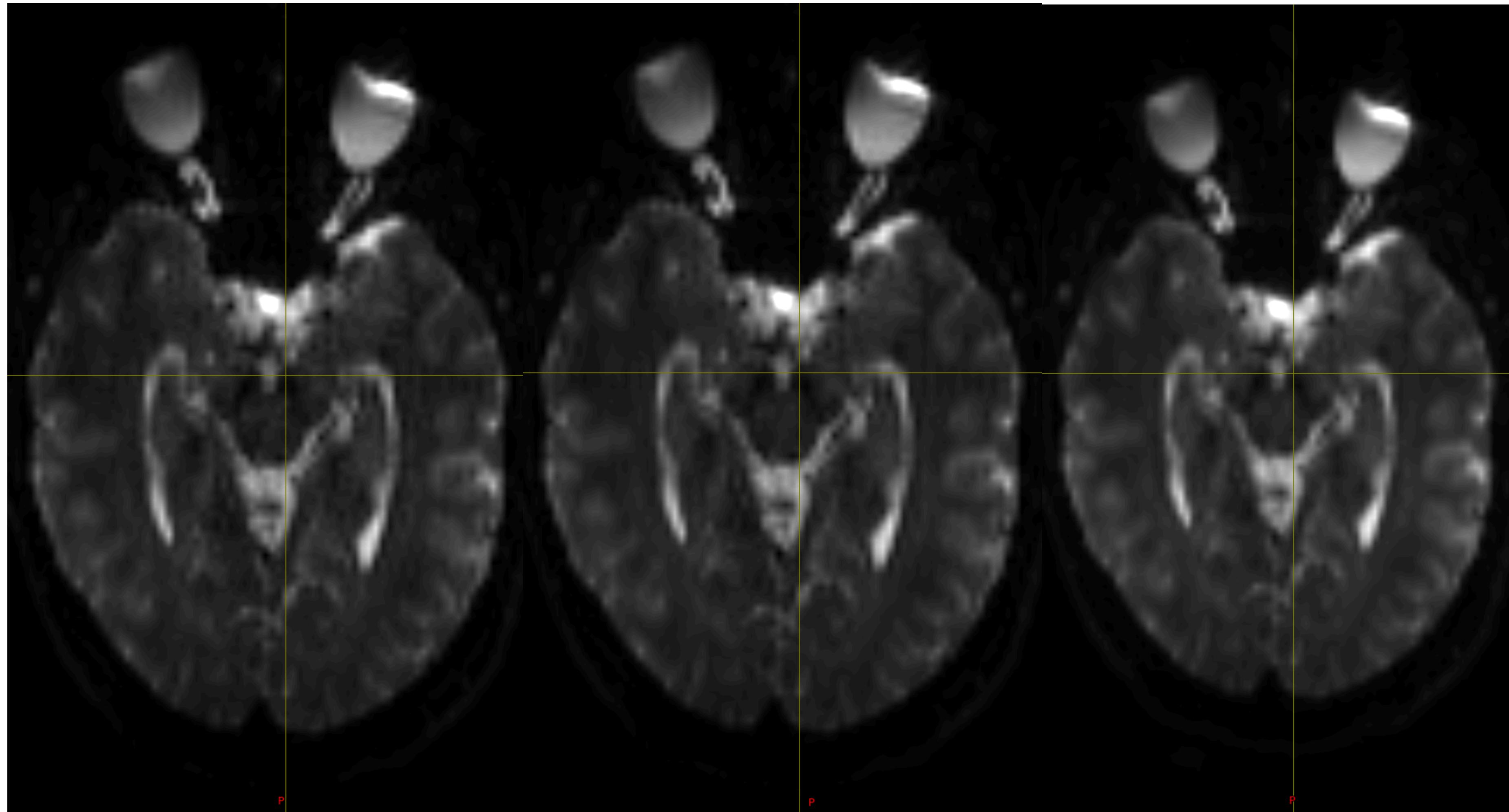
RAW_DWI_shells



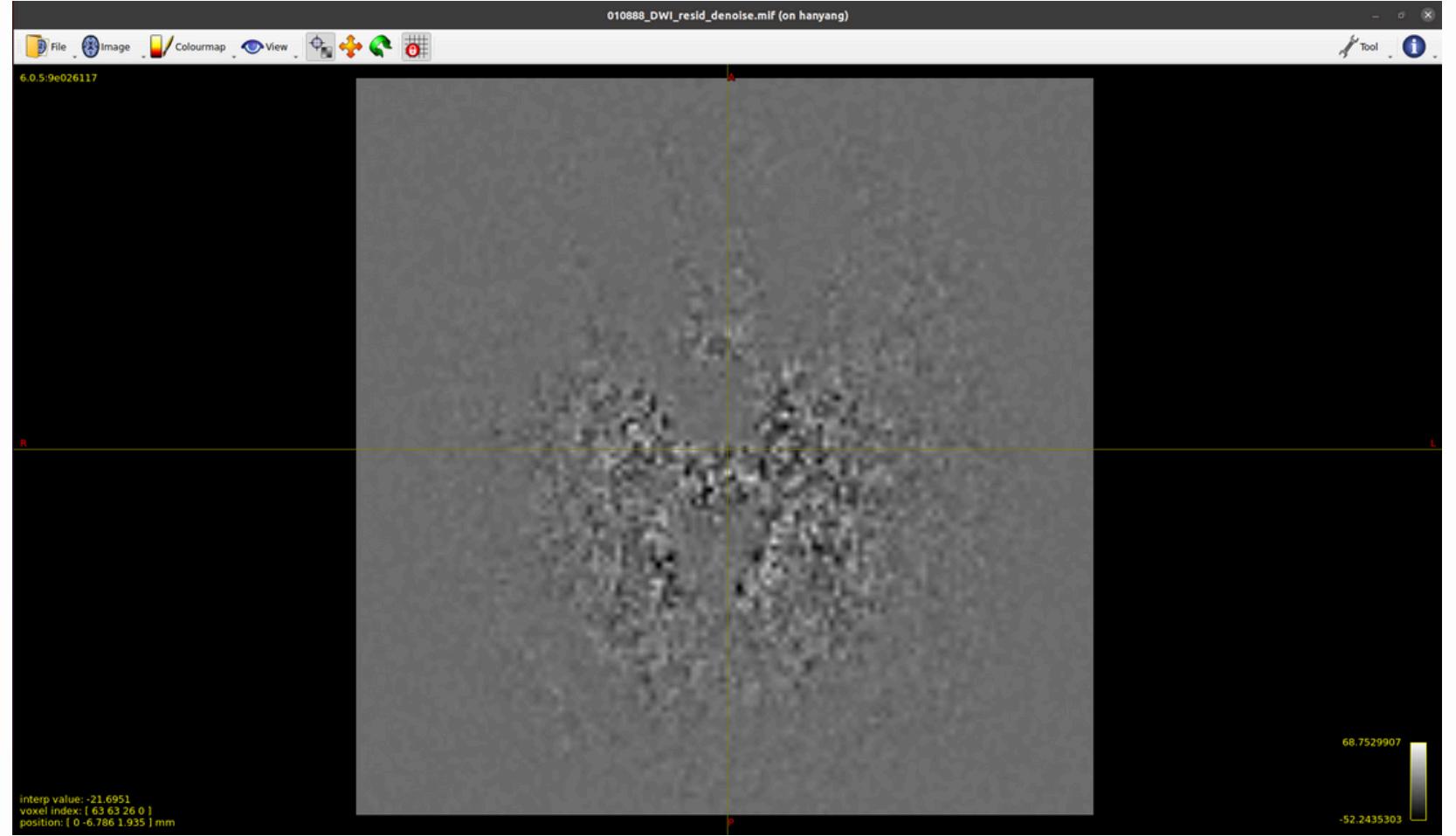
denoise



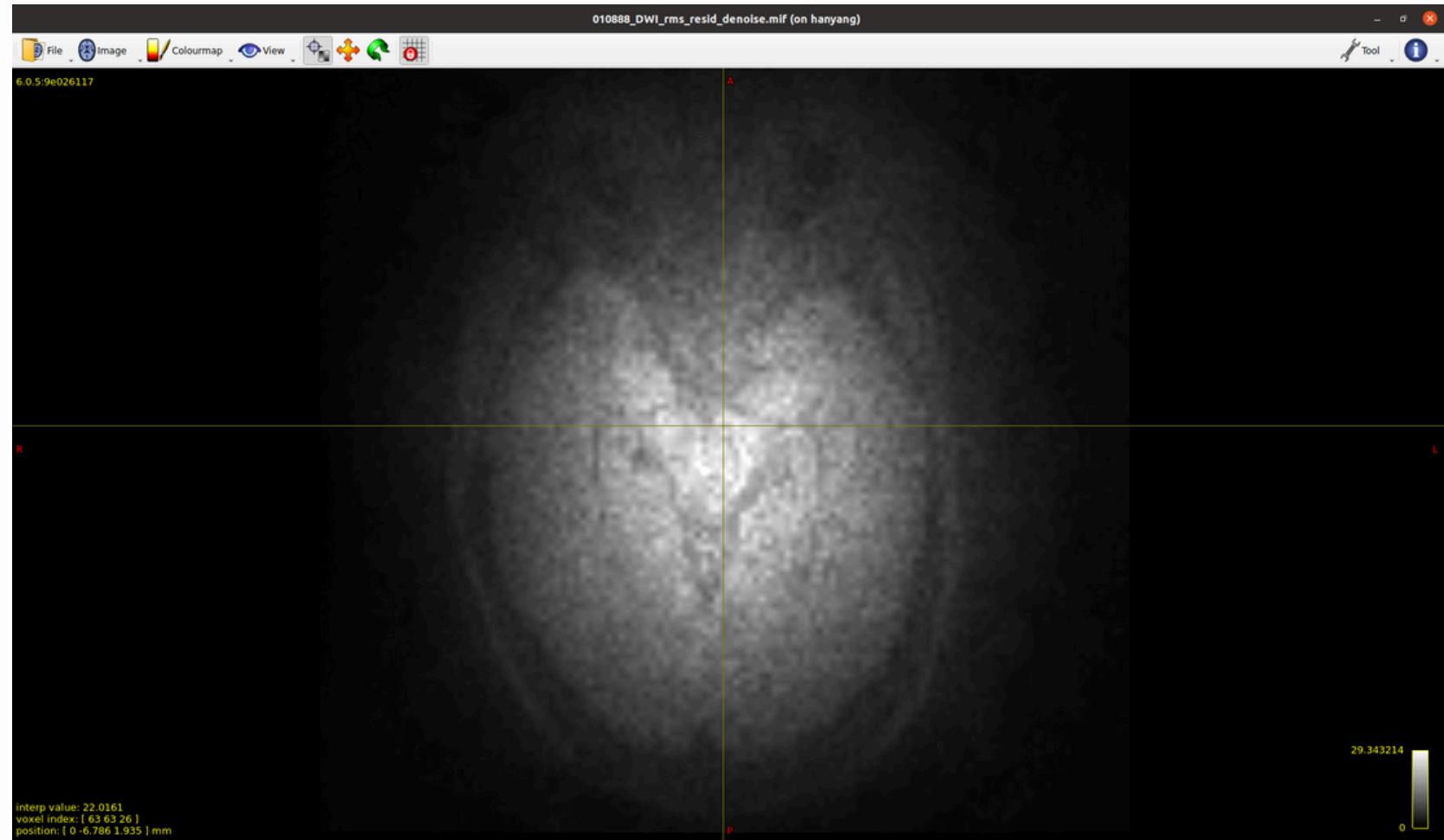
degibbs



resid denoise



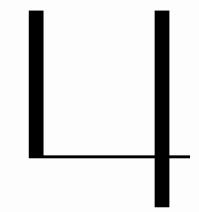
rms resid denoise



resid degibbs



- Resid denoise and degibbs are used after making denoise and degibbs since there's some noise left.
- RMS resid denoise: uses the mean square root to see how was denoise applied in different regions



dMRI_pipeline_eddy_e2.sh

```
(dMRI_env) [hanyang:x86_64-Linux-MRI-team]...ra.perez/DWI_Ai$>/neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/scripts/dMRI_pipeline_eddy_e2.sh 010888 /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/010888 /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/COMPILED_RAW /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/dparameters.ini /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/010888/Diffusion/Preproc_files/PreEddy/010888_diffusion_params.json 100 3
```

```
/neuro/labs/grantlab/research/MRI_processing/alejandra.perez  
/DWI_Ai/010888/Diffusion/Preproc_files/Eddy
```

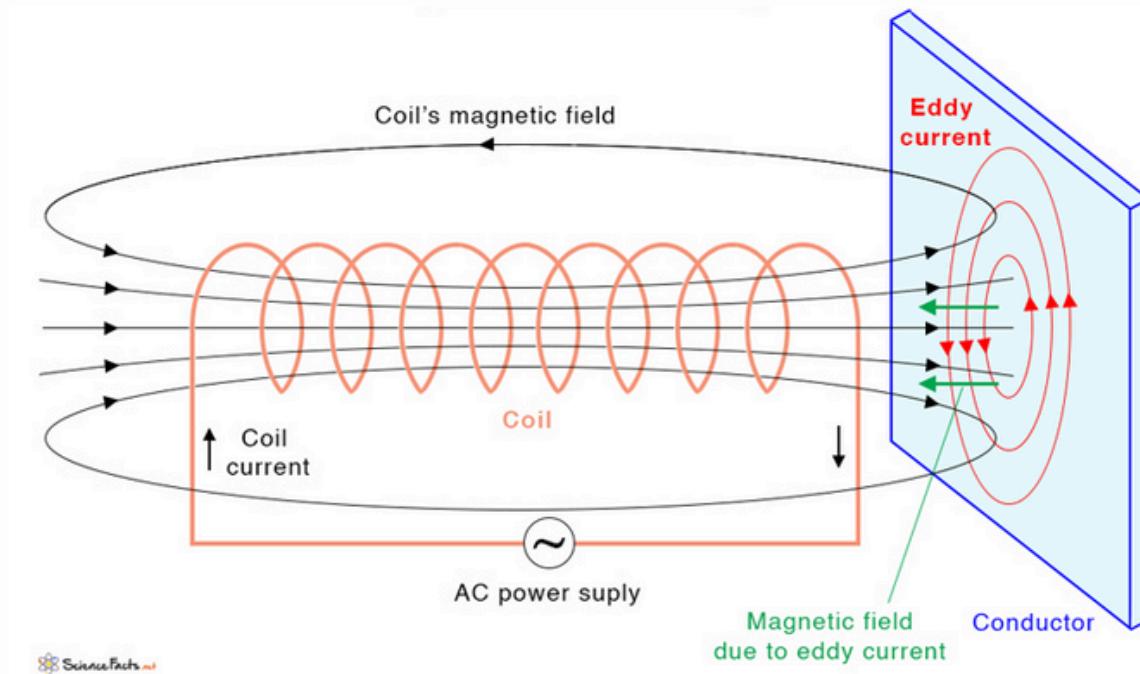
Outcomes

- Eddy directory is generated
- topup files
- preddy mask
- eddy.qc directory is created
- qc pdf
- outlier vols
- Mask directory is created
- Mask files

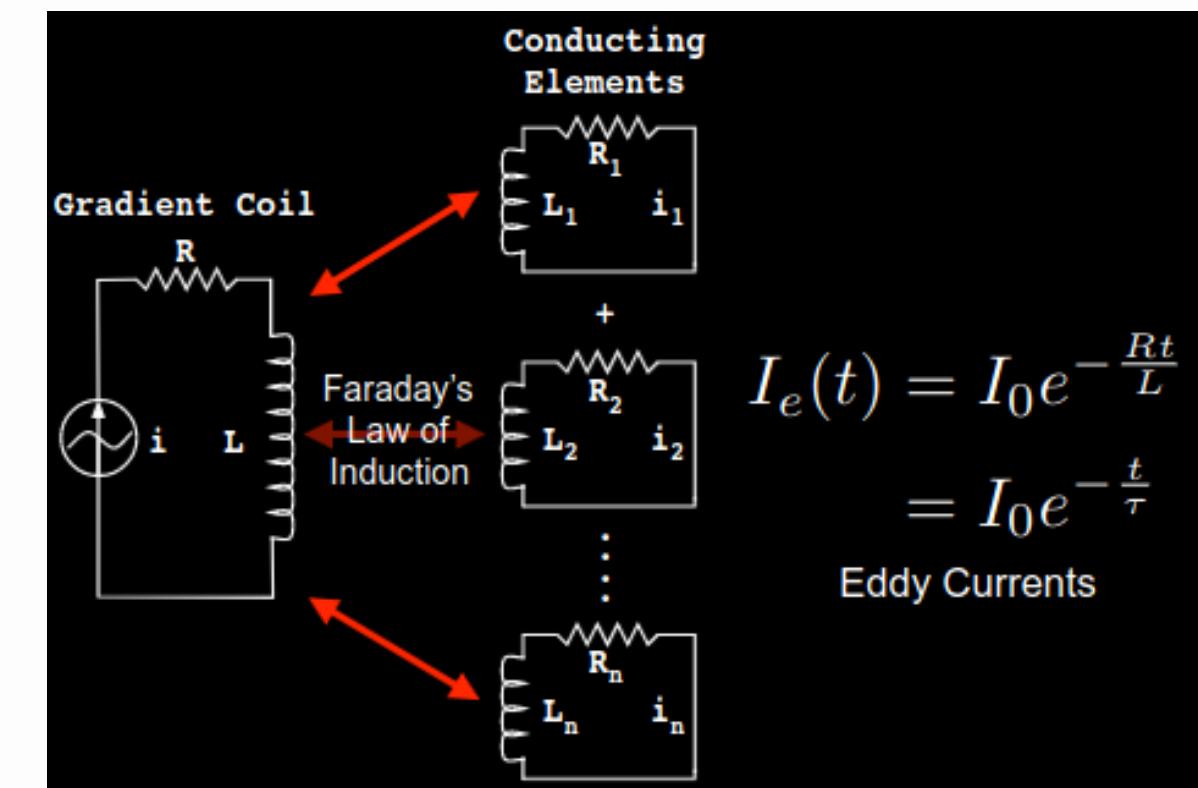
In diffusion MRI:

Eddy induced distortion is caused by a rapid on and off switching of diffusion gradients. This switching leads to currents in conducting structures that generating motion (data displacements) and distortions.

[6] Blommaert, J, Christiaens, D. (2023) Elsevier



[4] <https://www.sciencefacts.net/eddy-current.html>



[5] Ennis, D, et al. (2020) Stanford

```
[alejandra.perezyaned@hanyang:x86_64-Linux]...ra.perez/DWI_Ai$>tree 010888/Diffusion/Preproc_files/Eddy
```

Topup

- Topup is a tool that estimates and corrects susceptibility induced distortions. Susceptibility induced distortions produce artifacts due to the inhomogeneities of magnetic field inside the subject tested.

Eddy

- Eddy has the objective of correcting eddy current-induced distortions and subject movements.

ANTs

- Advance Normalization Tools (ANTs) is used to extract information from imaging data. It offers deformable normalization and segmentation functionality.

Eddy qc

- Consists of 2 tools: QUAD generates single subject reports and stores qa per subject; SQUAD reads QUAD outputs and generates study-wise reports. It can also update subjects reports

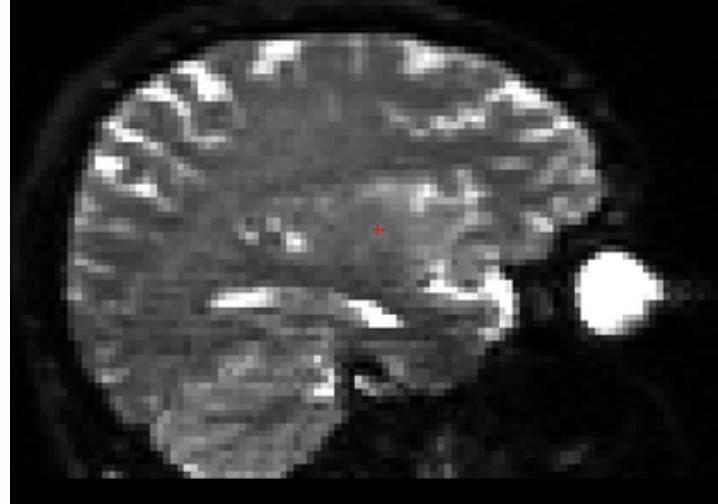
FSL_topup_010888_acq.txt

initial acq params and phase encoding

```
0 -1 0 0.0333
0 1 0 0.0333
0 -1 0 0.0333
0 1 0 0.0333
```

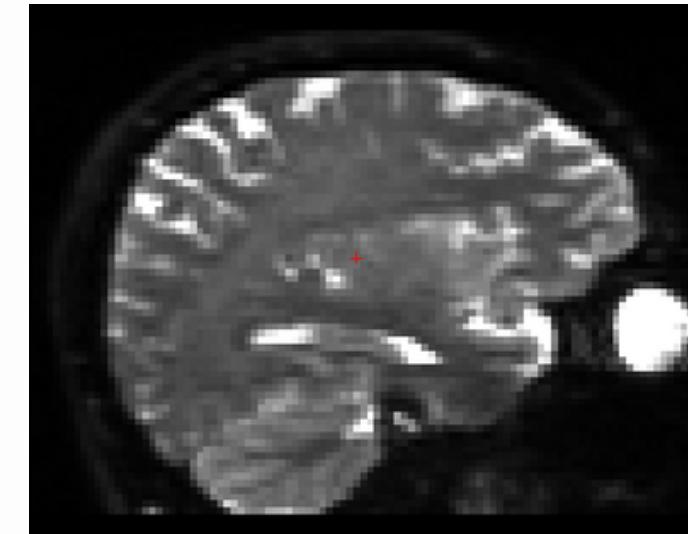
hifi_b0.nii.gz

AP/PA volumes, typically with different phase encoding-parameters (whole skull)



hifi_b0ave.nii.gz

AP/PA volumes average



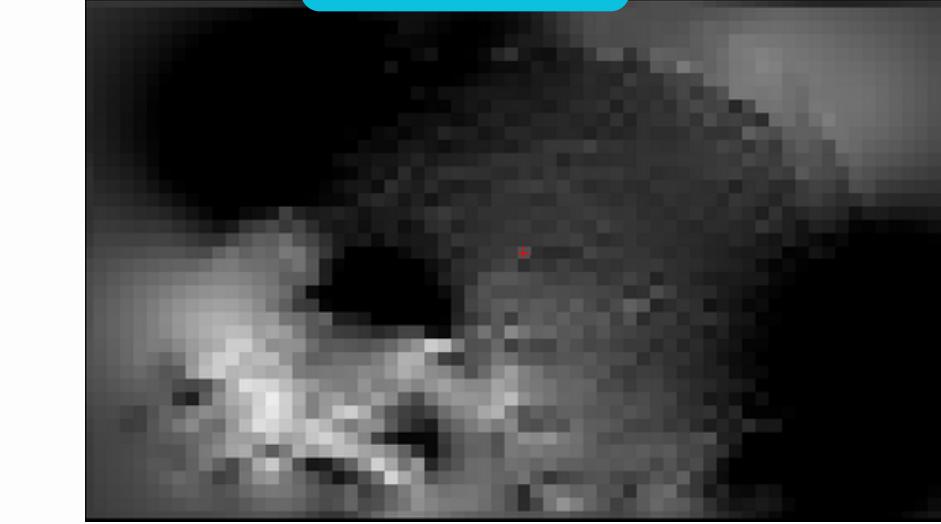
topupOut_movpar.txt

first 3 columns represent translations and next 3 represent rotations.

```
0 0 0 0 0 0
0.113109705 0 0.07438871021 -0.002026925864 -0.0003131829066 -0.002350159551
0.08510411148 0.3554202523 -0.08443416914 -0.000684538451 0.0007497524334 -0.004145659073
0.09234721029 -0.0806761305 -0.08966501152 -0.00151133226 6.885530255e-05 -0.003235919212
```

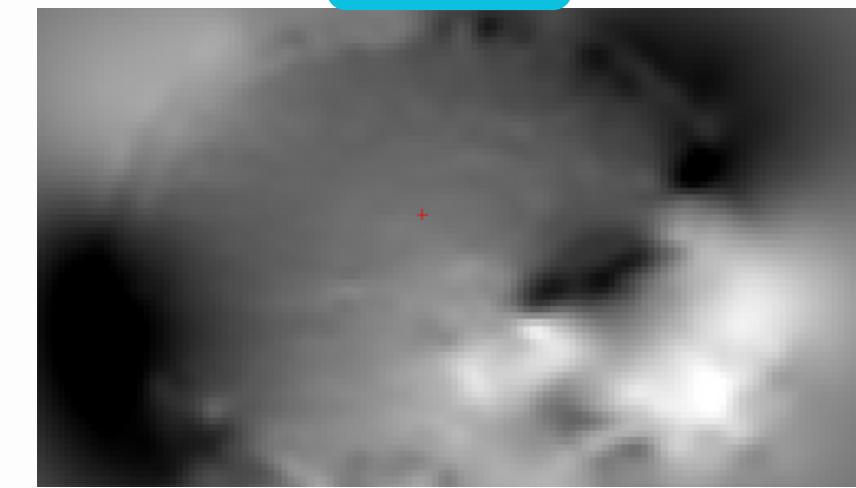
topupOut_fieldcoef.nii.gz

Top-up storage of the field (spline coefficients)



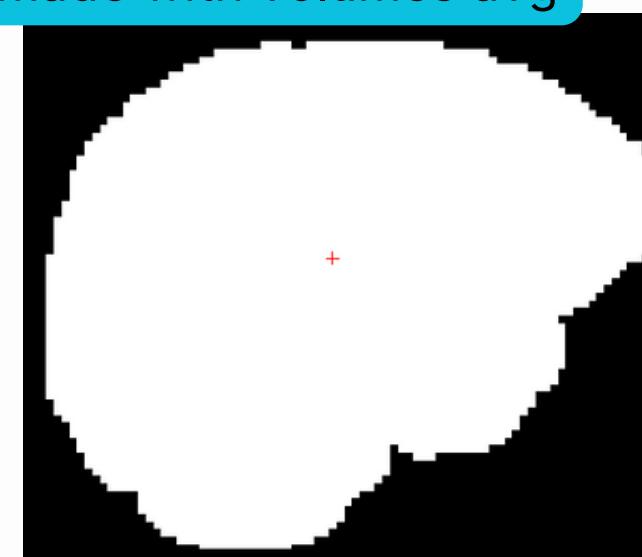
topupOut_field.nii.gz

How top-up thinks the off-resonance looks like



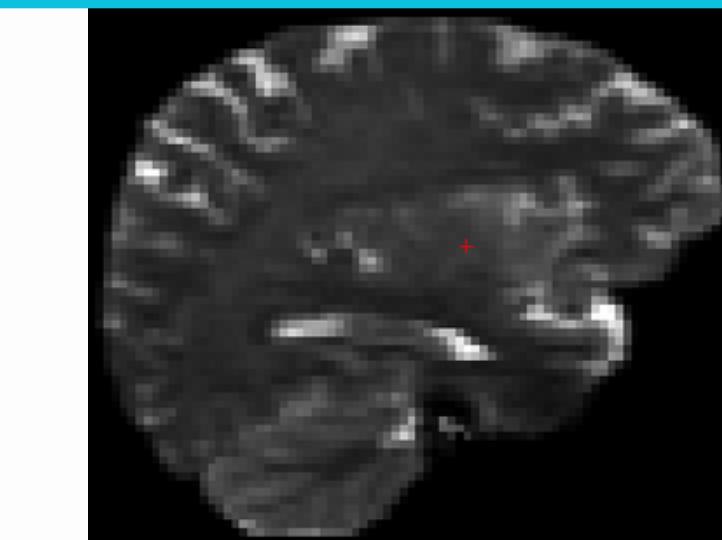
hifi_b0_brain_mask.nii.gz

AP/PA temporal mask for eddy, made with volumes avg



hifi_b0_brain.nii.gz

AP/PA volumes, typically with different phase encoding-parameters (only brain)



010888/Diffusion/Preproc_files/Eddy

010888_bias.mif post-eddy bias field

010888_DWI_fsl.bval b-values

010888_DWI_fsl.bvec normalized diffusion gradients

010888_eddy.eddy_cnr_maps.nii.gz SNR volume for b=0 and CNR volumes for remaining b-values

010888_eddy.eddy_command.txt

010888_eddy.eddy_movement_over_time translations and rotations (volumes*slices)/Multi-band factor

010888_eddy.eddy_movement_rms summary of total movement in each volume

010888_eddy.eddy_outlier_free_data.nii.gz original data not corrected for susceptibility or EC with outlier slices replaced by Gaussian [predictions]

010888_eddy.eddy_outlier_map numeric matrix. 0=scan slice is not an outlier, 1=it is an outlier

010888_eddy.eddy_outlier_n_sqr_stdev_map numeric matrix. how many stdv off the mean difference between observation and prediction is

010888_eddy.eddy_outlier_n_stdev_map numeric matrix. how many stdv off the sqrt of the mean difference between observation and prediction is

010888_eddy.eddy_outlier_report outlier slices that eddy has found

010888_eddy.eddy_parameters translations, rotations and induced fields

010888_eddy.eddy_post_eddy_shell_alignment_parameters movement parameters between shells

010888_eddy.eddy_post_eddy_shell_PE_translation_parameters movement parameters between shells in PE direction

010888_eddy.residuals.nii.gz difference between observation and prediction. Same order and number of volumes as input

010888_eddy.eddy_restricted_movement_rms movementRMS which disregards translation in PE direction

010888_eddy.eddy_rotated_bvecs bvecs totations if movement was observed

010888_eddy.eddy_values_of_all_input_parameters

010888_eddy.mif edy corrected DWI volume

010888_eddy.nii.gz main output: input data after correction for eddy currents, susceptibility and signal drop-out

010888_FSL_eddy_b0s.nii.gz AP/PA volumes

010888_FSL_eddy_b0s.topup_log top up output

010888_unbiased.mif

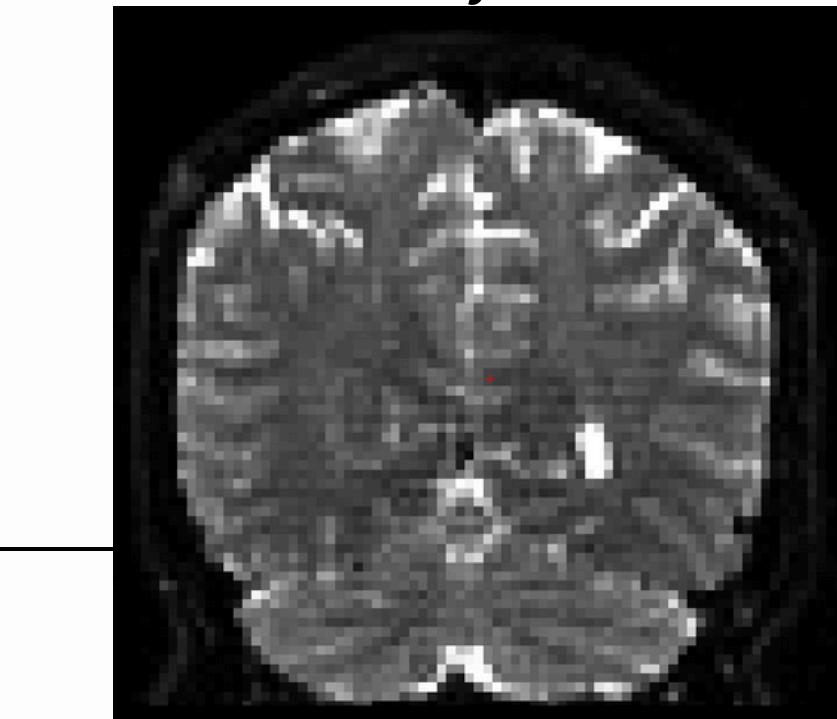
010888_unbiased.nii.gz post-eddy bias field corrected

010888_unbiased.nii.nii.gz

FSL_eddy_010888_index.txt relationship between orig images, acqp and topup

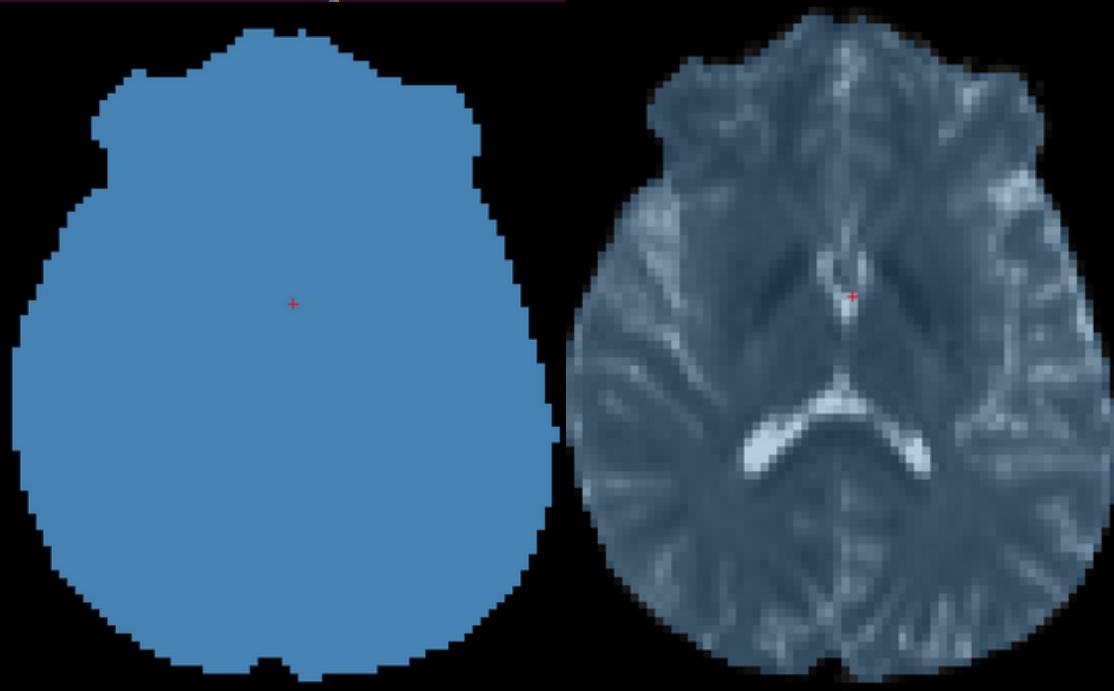
FSL_eddy_010888_slspec.txt describes slices/MB-groups (simultaneous multi slice)

eddy_b0s



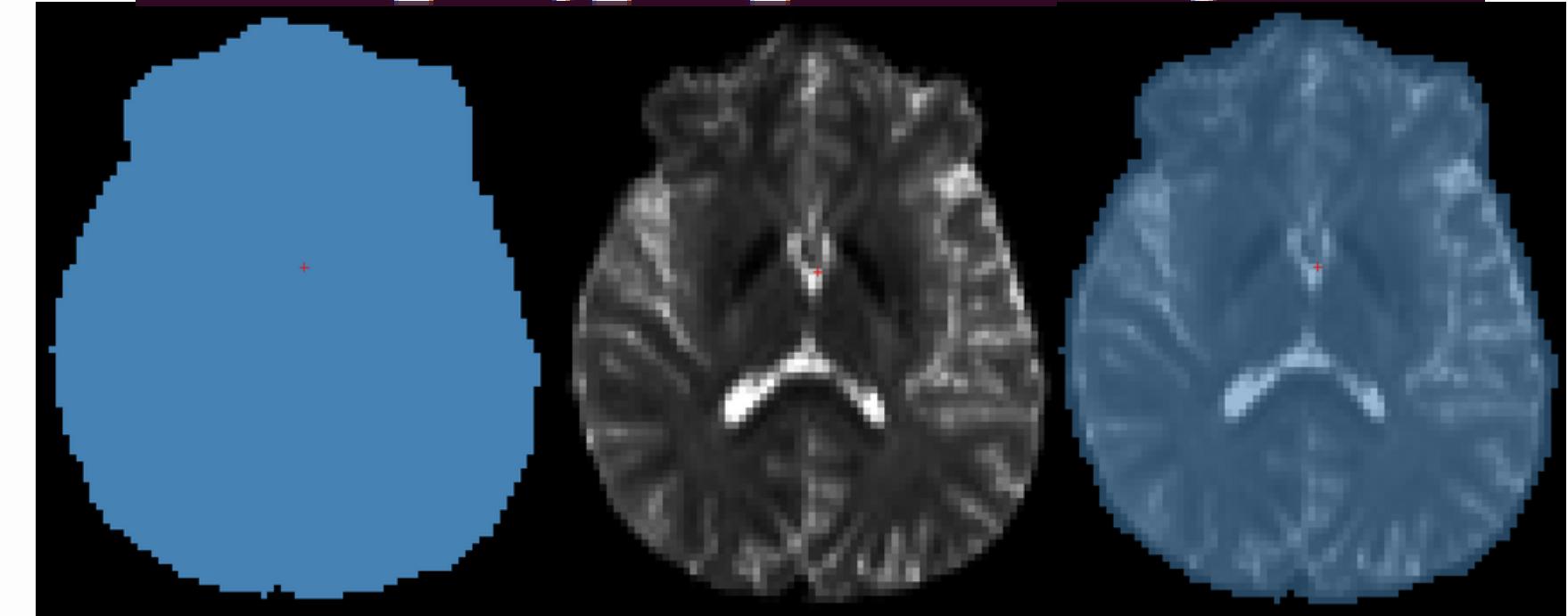
brain mask pre-bias

010888_eddy_brain_mask.mif
010888_eddy_brain_mask.nii.gz



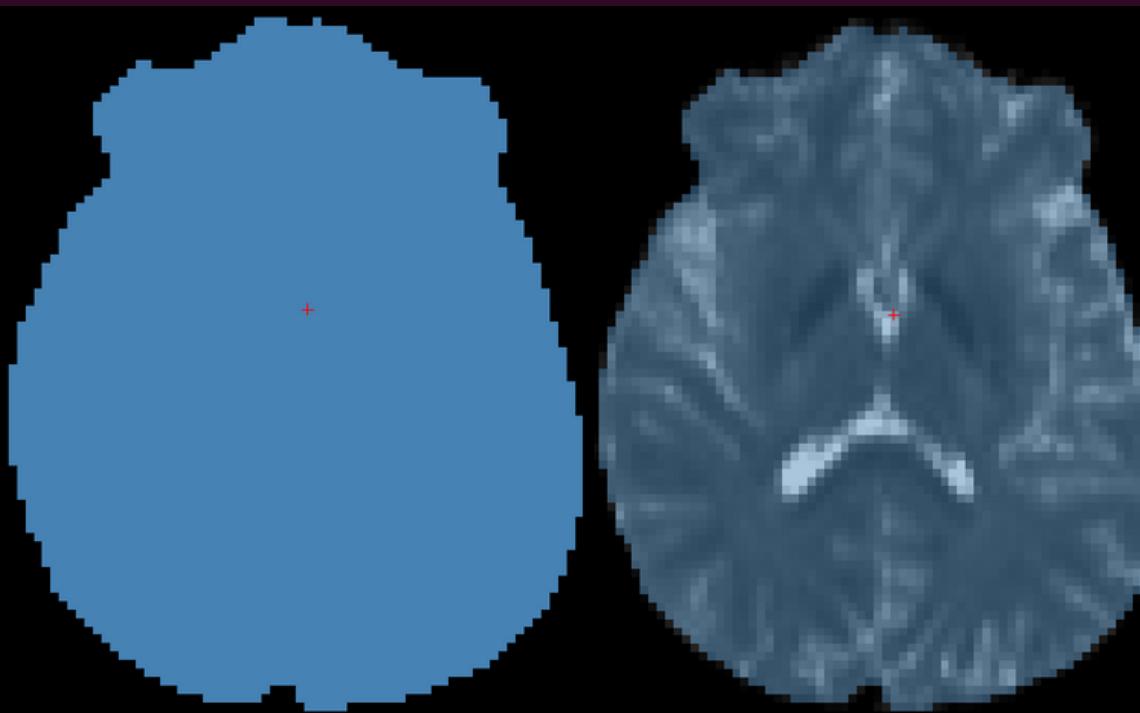
brain mask pre-bias correction

010888_eddy_bet_brain_mask.nii.gz
010888_eddy_bet_brain.nii.gz



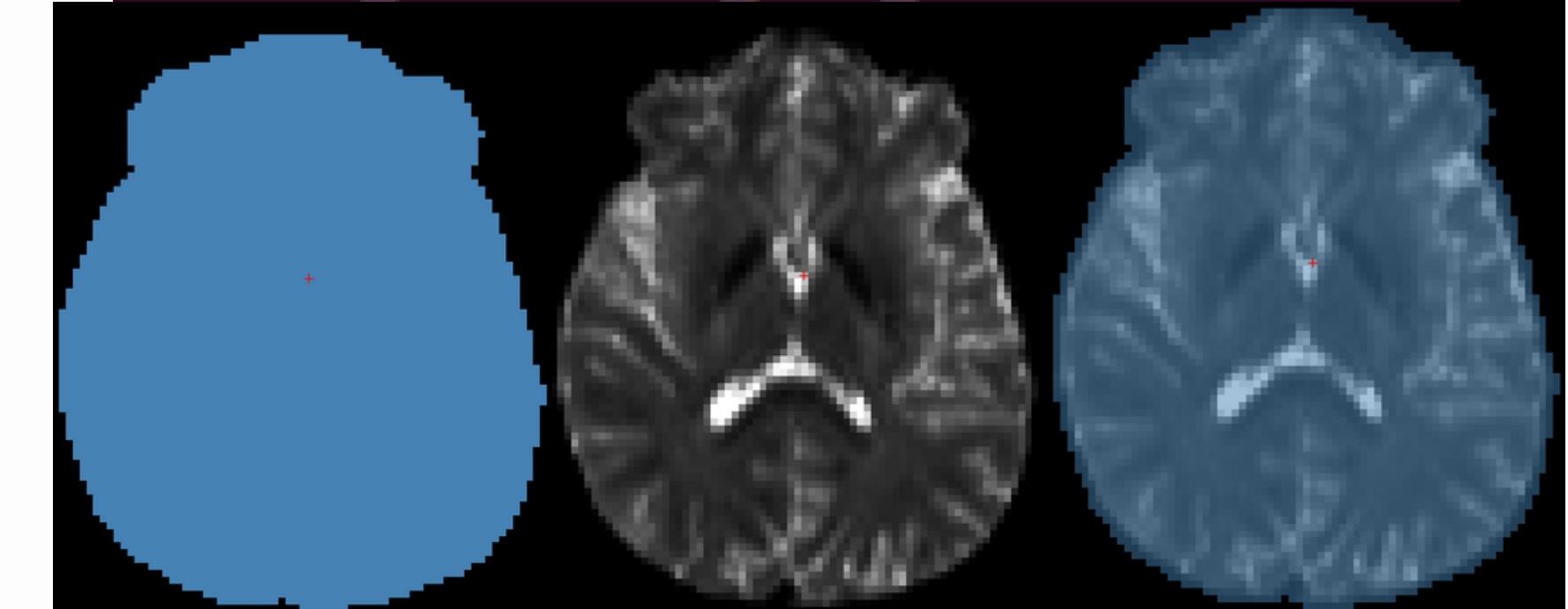
post bias brain mask

010888_unbiased_bet_brain_mask.nii.gz



post bias correction brain mask
brain mask post-bias correction

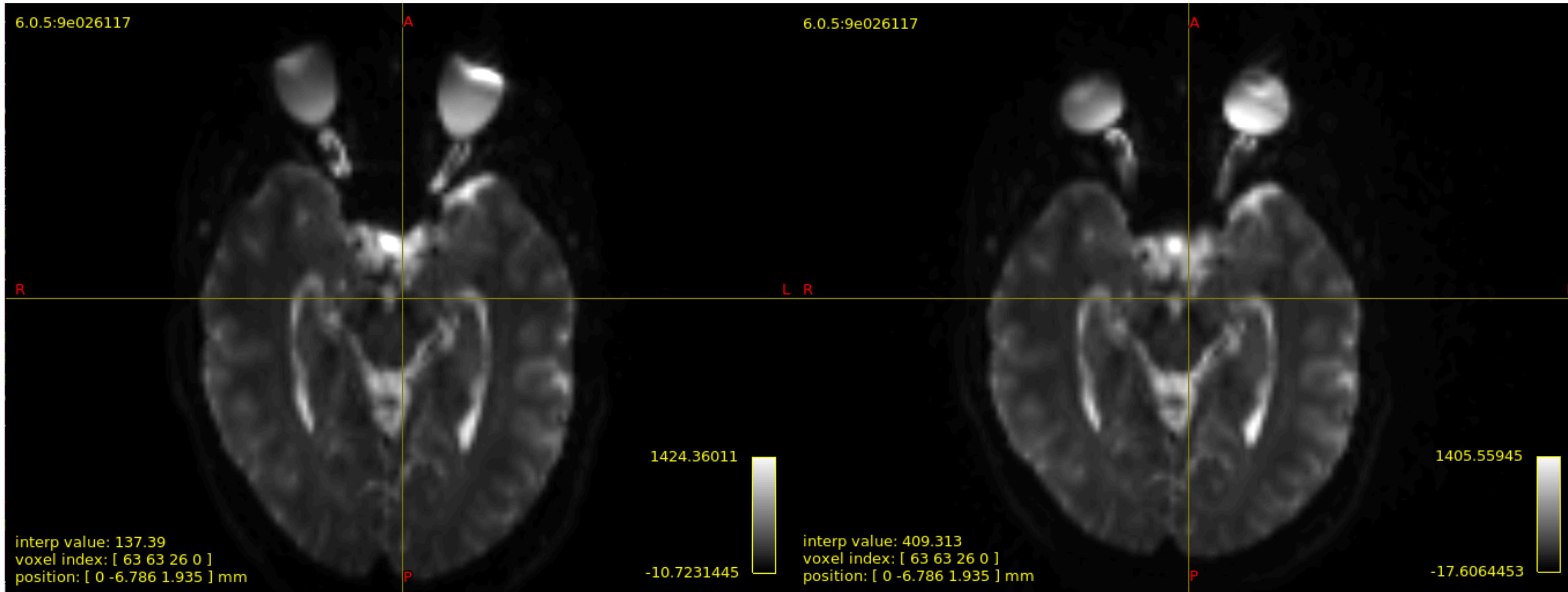
010888_unbiased_bet_brain_mask.nii.gz
010888_unbiased_bet_brain.nii.gz



degibbs



eddy.mif



interp value: 137.39
voxel index: [63 63 26 0]
position: [0 -6.786 1.935] mm

1424.36011

-10.7231445

interp value: 409.313
voxel index: [63 63 26 0]
position: [0 -6.786 1.935] mm

1405.55945

-17.6064453

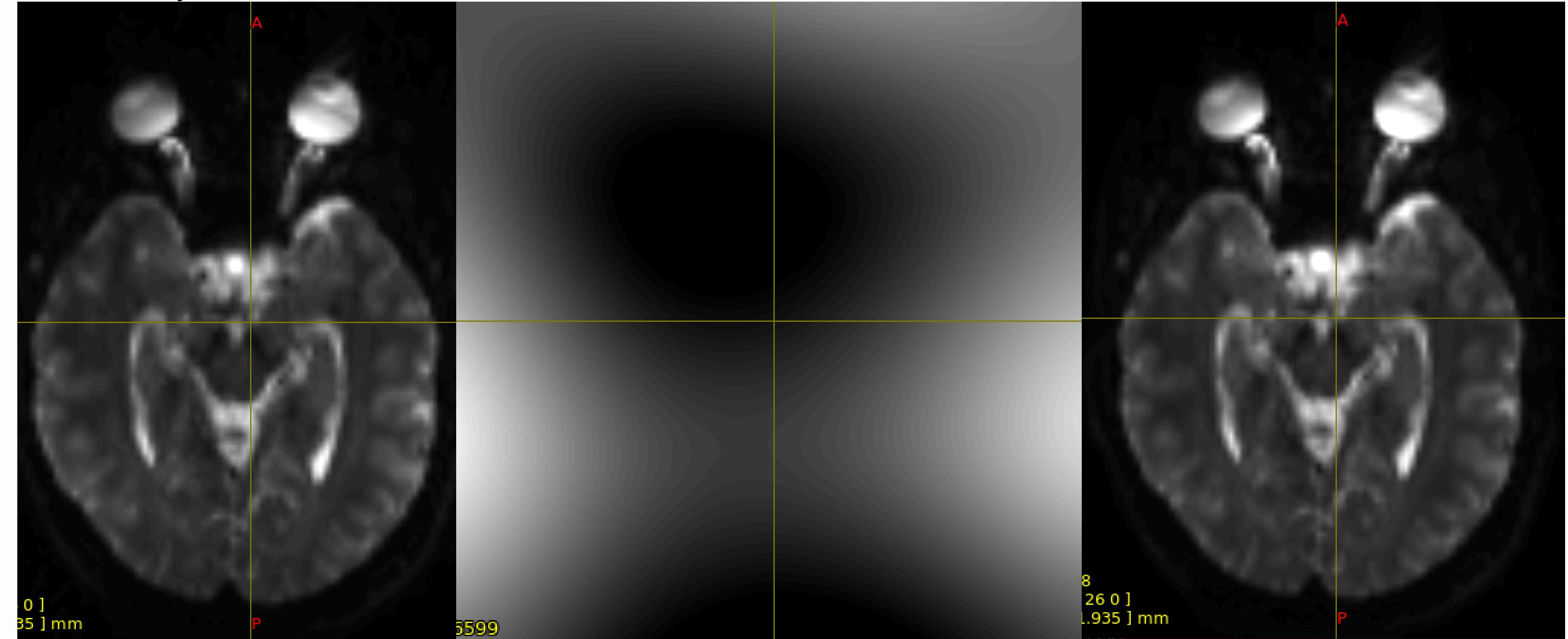
eddy.mif



bias.mif



unbiased.mif




```
(dMRI_env) [hanyang:x86_64-Linux-MRI-team]...proc_files/Eddy$>cat FSL_eddy_010888_index.txt  
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
```

```
FSL_eddy_010888_slspec.txt
```

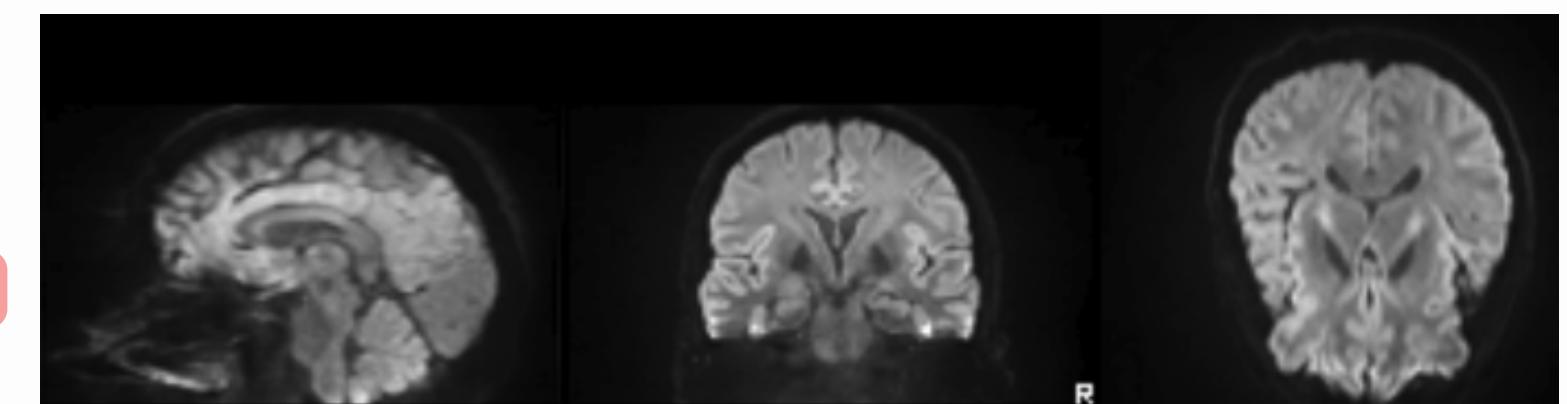
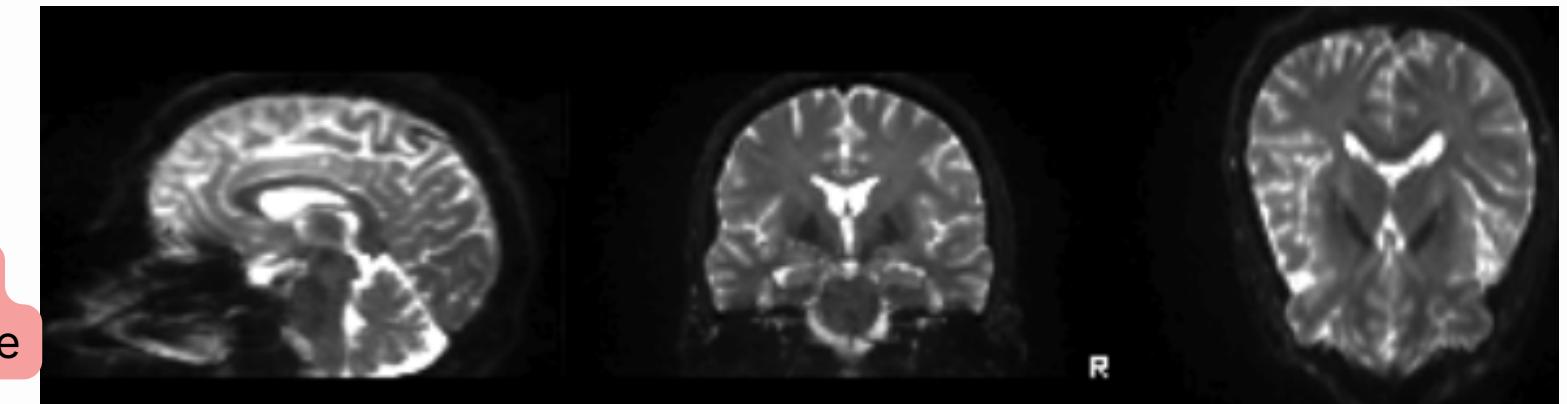
```
1 38  
3 40  
5 42  
7 44  
9 46  
11 48  
13 50  
15 52  
17 54  
19 56  
21 58  
23 60  
25 62  
27 64  
29 66  
31 68  
33 70  
35 72  
0 37  
2 39  
4 41  
6 43  
8 45  
10 47  
12 49  
14 51  
16 53  
18 55  
20 57  
22 59  
24 61  
26 63  
28 65  
30 67  
32 69  
34 71  
36 73
```

outlier_vols.txt
4 stdev away from mean slice
difference (Ai's)

2
12
27
36
49

010888_eddy.qc/
avg_b0_pe0.png

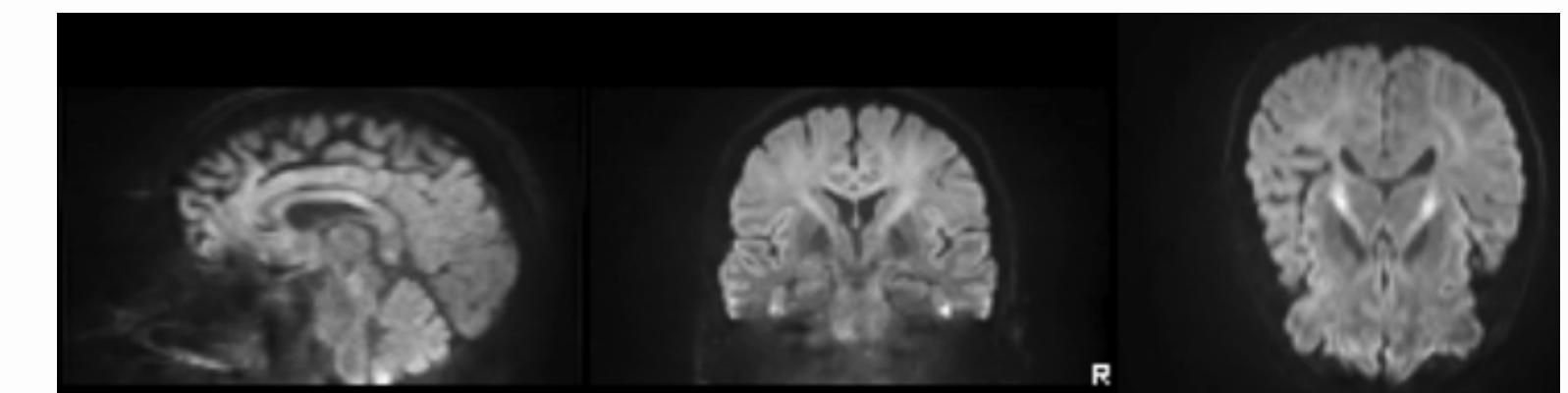
mid-sagittal, -coronal, -axial slices of
each averaged pe-direction b0 volume



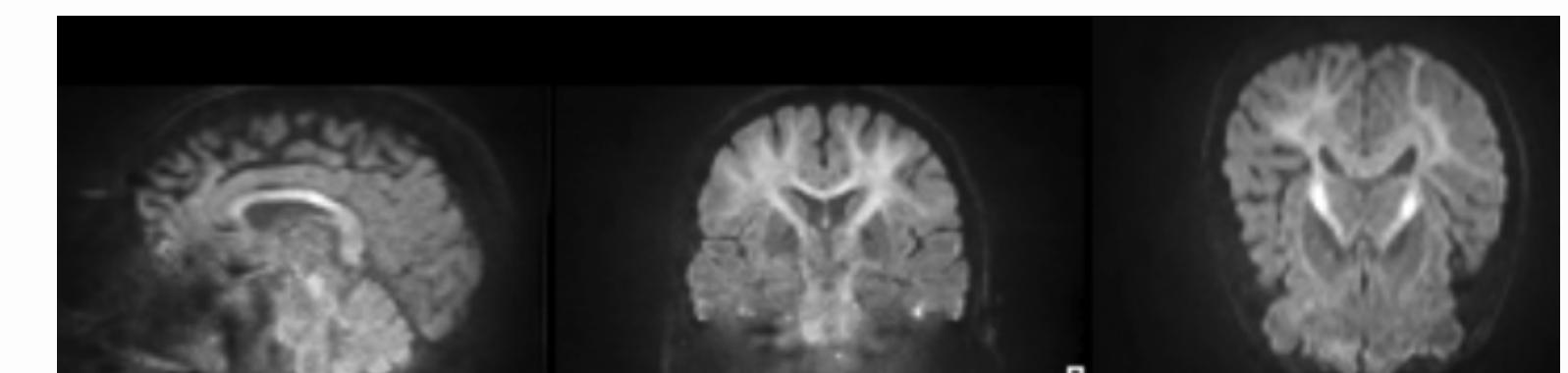
avg_b1000.png

mid-sagittal, -coronal, -axial slices of
each averaged b-shell volume

avg_b2000.png

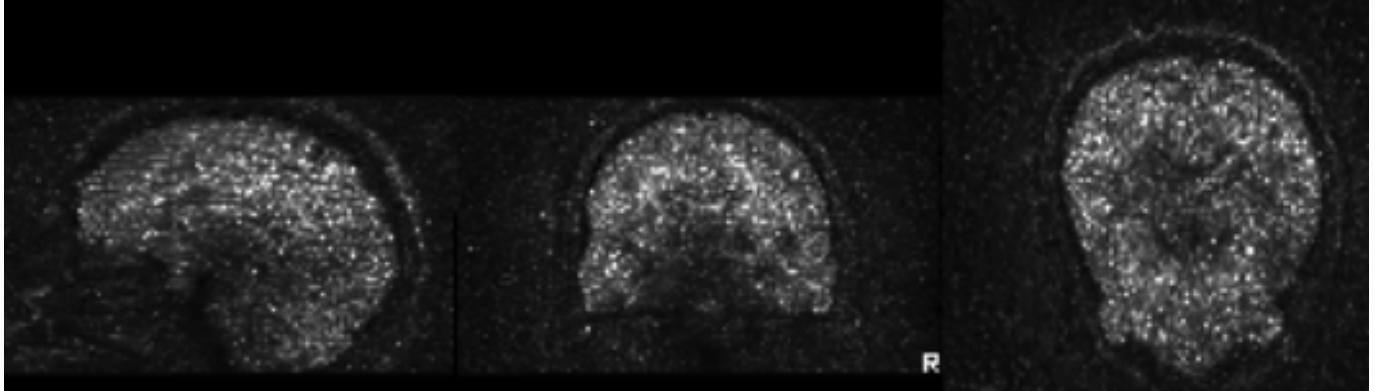


avg_b3000.png

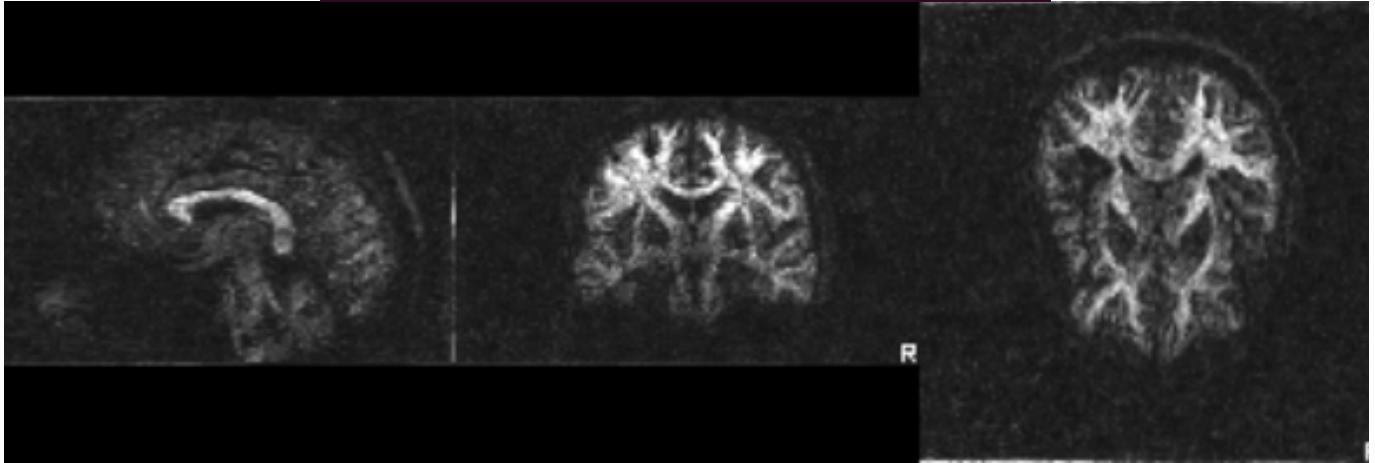


mid-sagittal, -coronal, -axial slices of each b-shell CNR volume

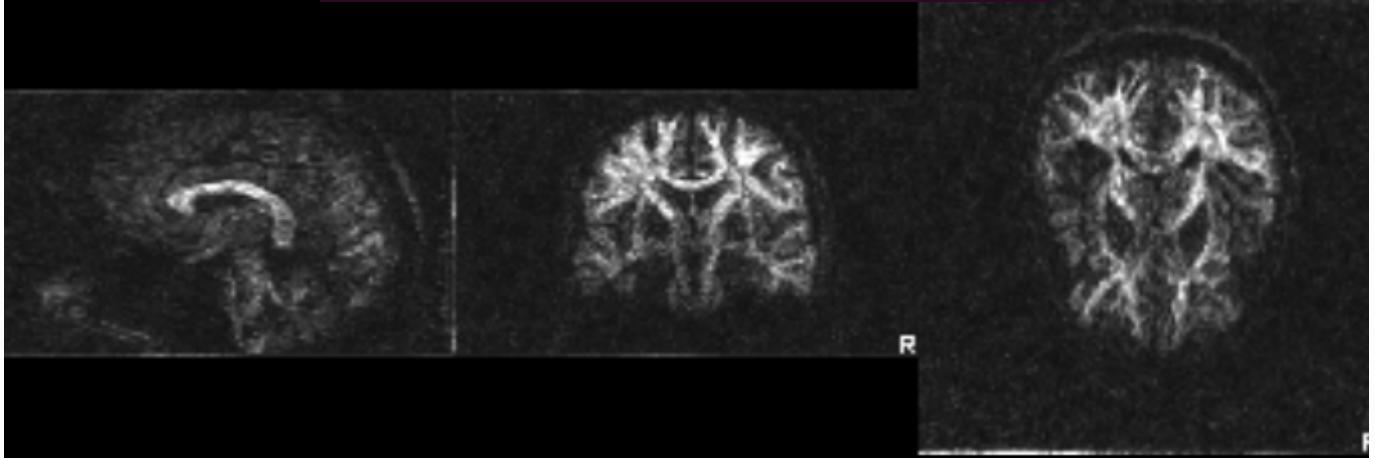
cnr0000.nii.gz.png



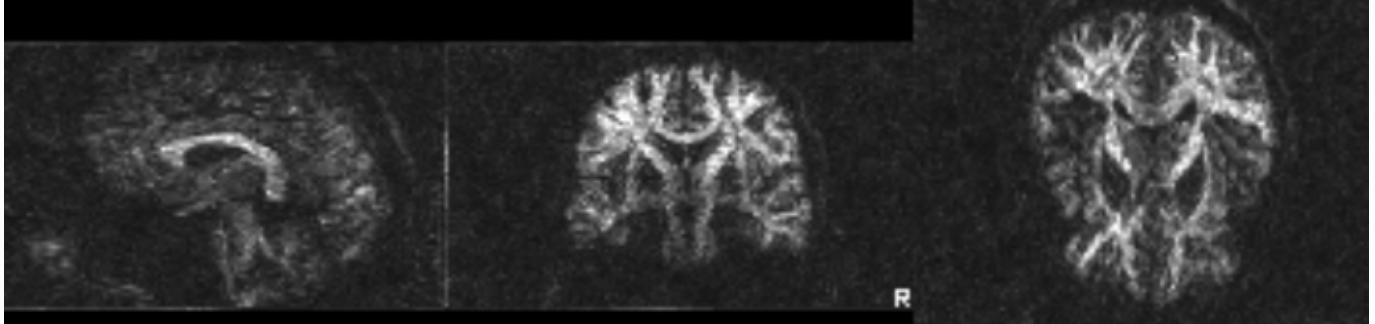
cnr0001.nii.gz.png



cnr0002.nii.gz.png

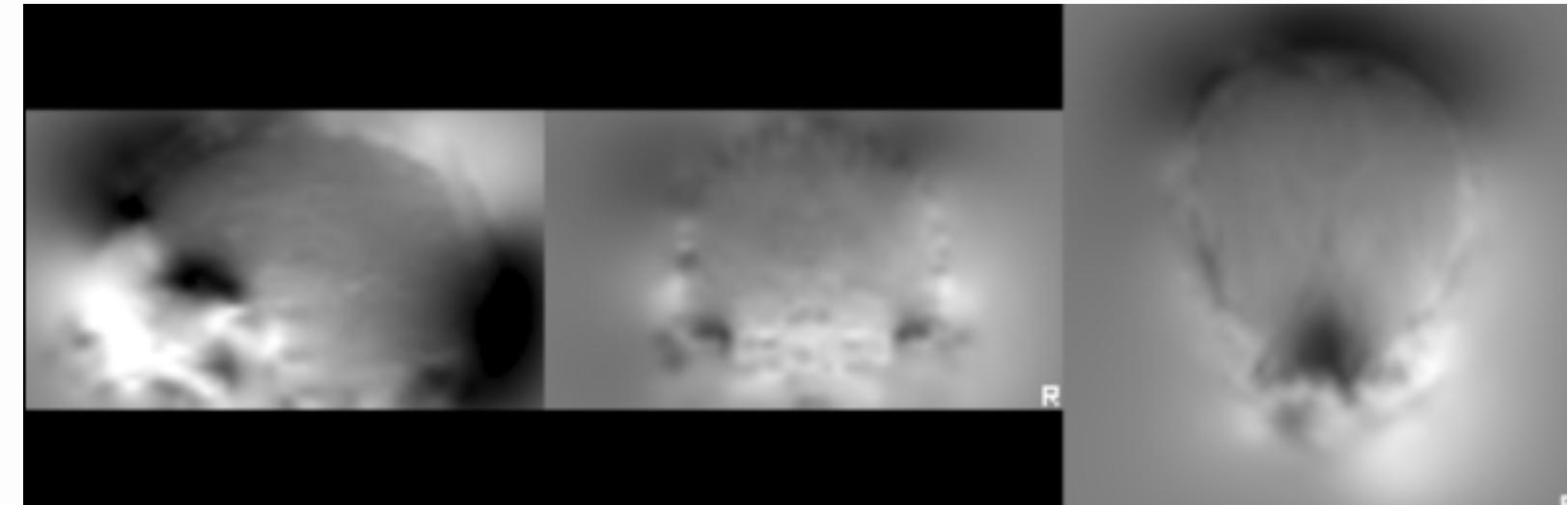


cnr0003.nii.gz.png



vdm.png

mid-sagittal, -coronal, -axial slices of voxel displacement map



```
[alejandra.perezyaned@hanyang:x86_64-Linux]...ra.perez/DWI_Ai$>tree 010888/Diffusion/Preproc_files/Eddy
```

Volume-wise mask-averaged square residuals

eddy_msr.txt

```
51.160366 57.663799 2.423743 1.821204 1.264418 2.745734 2.087434 1.321747 2.014697 1.848874 1.251073 2.140581 1.905393 1.269788 2.049171 1.855039 1.286605 1.911652 1.783993 1.203945 2.051316 1.781346 53.  
419140 1.211430 1.861697 1.799858 1.211980 2.052240 1.834146 1.220829 2.042400 1.846382 1.201018 1.956207 1.805425 1.228680 2.860147 1.967736 1.228298 2.006734 1.873268 1.249302 2.065981 56.581455 1.8338  
20 1.192419 2.029242 1.690249 1.134007 2.062691 1.797572 1.210702 2.128155 1.854736 1.359401 2.590694 1.960296 1.292687 2.350960 1.751823 1.244642 2.295056 1.818340 1.281800 112.332794
```

eddy_quad_010888_acq.txt

0 -1 0 0.0333

qc.json

Database with quality metrics and data info

Residuals represent the difference between observed volumes and the expected ones, they are squared and averaged to look at the discrepancy of outcomes.



Single subject QC report generated using eddy quad v1.0.3

When using eddy and its QC tools, we ask you to please reference the papers describing the different aspects of the modelling and corrections. The following suggestion for a methods section and list of references has been tailored for you based on your eddy command line.

METHODS

The susceptibility induced off-resonance field was estimated from spin-echo EPI images acquired with different phase-encode directions (Andersson et al., 2003). This field was passed to "eddy", a tool that combined it with estimating gross subject movement and eddy current-induced distortions (Andersson & Sotiropoulos, 2016). The quality of the dataset was assessed using the eddy QC tools (Bastiani et al., 2019). Slices with signal loss caused by subject movement coinciding with the diffusion encoding were detected and replaced by predictions made by a Gaussian Process (Andersson et al., 2016). Intra-volume subject movement, leading to disjoint slices that when stacked does not amount to a valid volumetric representation of the object, was corrected using slice-to-volume alignment (Andersson et al., 2017).

REFERENCES

Jesper L.R. Andersson, Stefan Skare and John Ashburner. 2003. How to correct susceptibility distortions in spin-echo echo-planar images: application to diffusion tensor imaging. *NeuroImage* 20:870-888

Jesper L.R. Andersson and Stamatis N. Sotiropoulos. 2016. An integrated approach to correction for off-resonance effects and subject movement in diffusion MR imaging. *NeuroImage* 125:1063-1078

Matteo Bastiani, Michiel Cottaar, Sean P. Fitzgibbon, Sana Suri, Fidel Alfaro-Almagro, Stamatis N. Sotiropoulos, Saad Jbabdi and Jesper L.R. Andersson. 2019. Automated quality control for within and between studies diffusion MRI data using a non-parametric framework for movement and distortion correction. *NeuroImage* 184:801-812

Jesper L.R. Andersson, Mark S. Graham, Eniko Zsoldos and Stamatis N. Sotiropoulos. 2016. Incorporating outlier detection and replacement into a non-parametric framework for movement and distortion correction of diffusion MR images. *NeuroImage* 141:556-572

Jesper L.R. Andersson, Mark S. Graham, Ivana Drobniak, Hui Zhang, Nicola Filippini and Matteo Bastiani. 2017. Towards a comprehensive framework for movement and distortion correction of diffusion MR images: Within volume movement. *NeuroImage* 152:450-466

Volume-to-volume motion

Average abs. motion (mm)	0.55
Average rel. motion (mm)	0.29
Average x translation (mm)	-0.06
Average y translation (mm)	0.39
Average z translation (mm)	-0.04
Average x rotation (deg)	0.03
Average y rotation (deg)	-0.06
Average z rotation (deg)	-0.28

Within-volume motion

Avg std x translation (mm)	0.01
Avg std y translation (mm)	0.03
Avg std z translation (mm)	0.04
Avg std x rotation (deg)	0.05
Avg std y rotation (deg)	0.04
Avg std z rotation (deg)	0.03

Outliers

Total outliers (%)	0.27
Outliers ($b=1000 \text{ s/mm}^2$)	0.61
Outliers ($b=2000 \text{ s/mm}^2$)	0.20
Outliers ($b=3000 \text{ s/mm}^2$)	0.00
Outliers (PE dir=[0. -1. 0.])	0.25

SNR/CNR

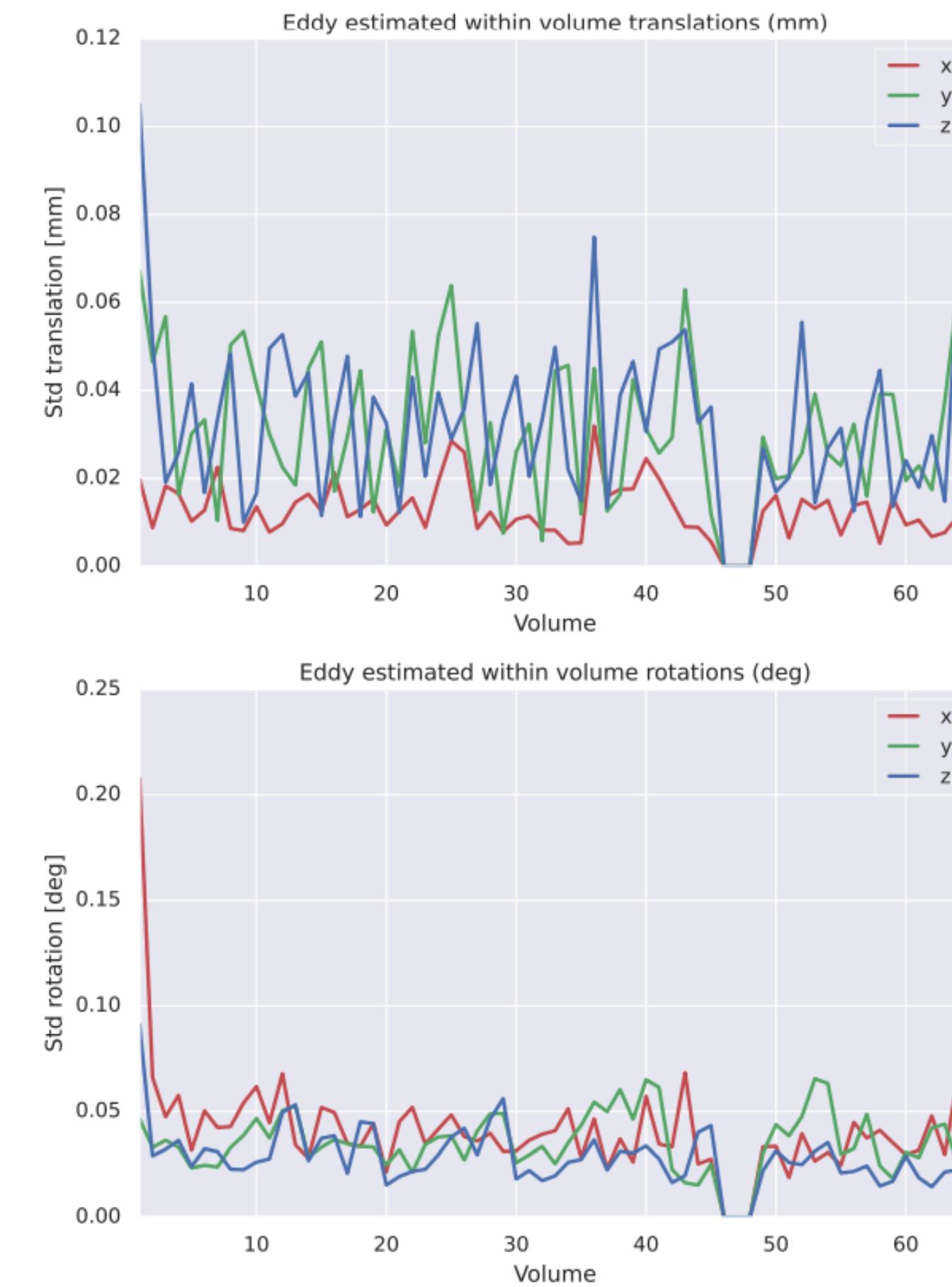
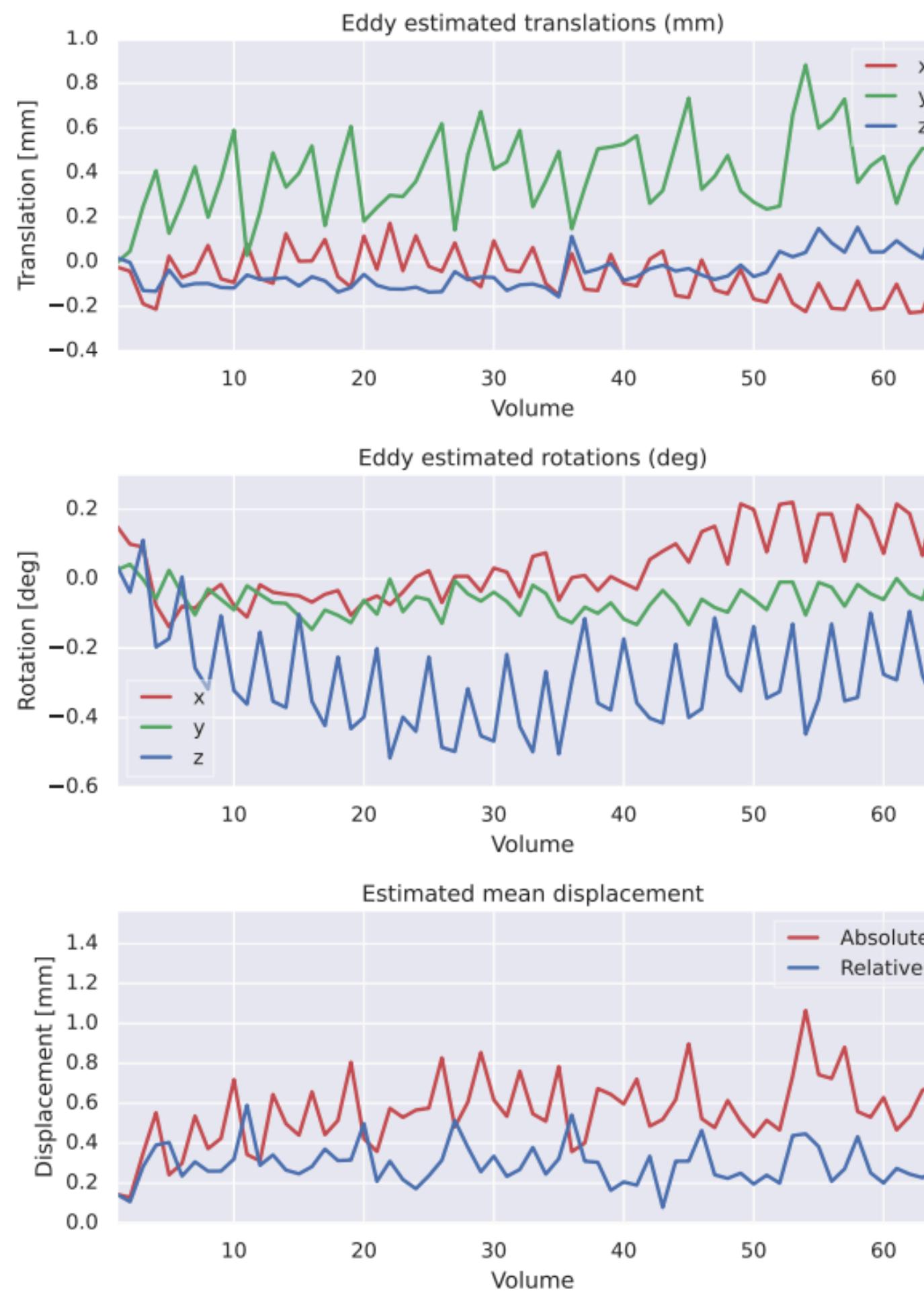
Average SNR ($b=0 \text{ s/mm}^2$)	30.74
Average CNR ($b=1000 \text{ s/mm}^2$)	2.59
Average CNR ($b=2000 \text{ s/mm}^2$)	2.52
Average CNR ($b=3000 \text{ s/mm}^2$)	2.72

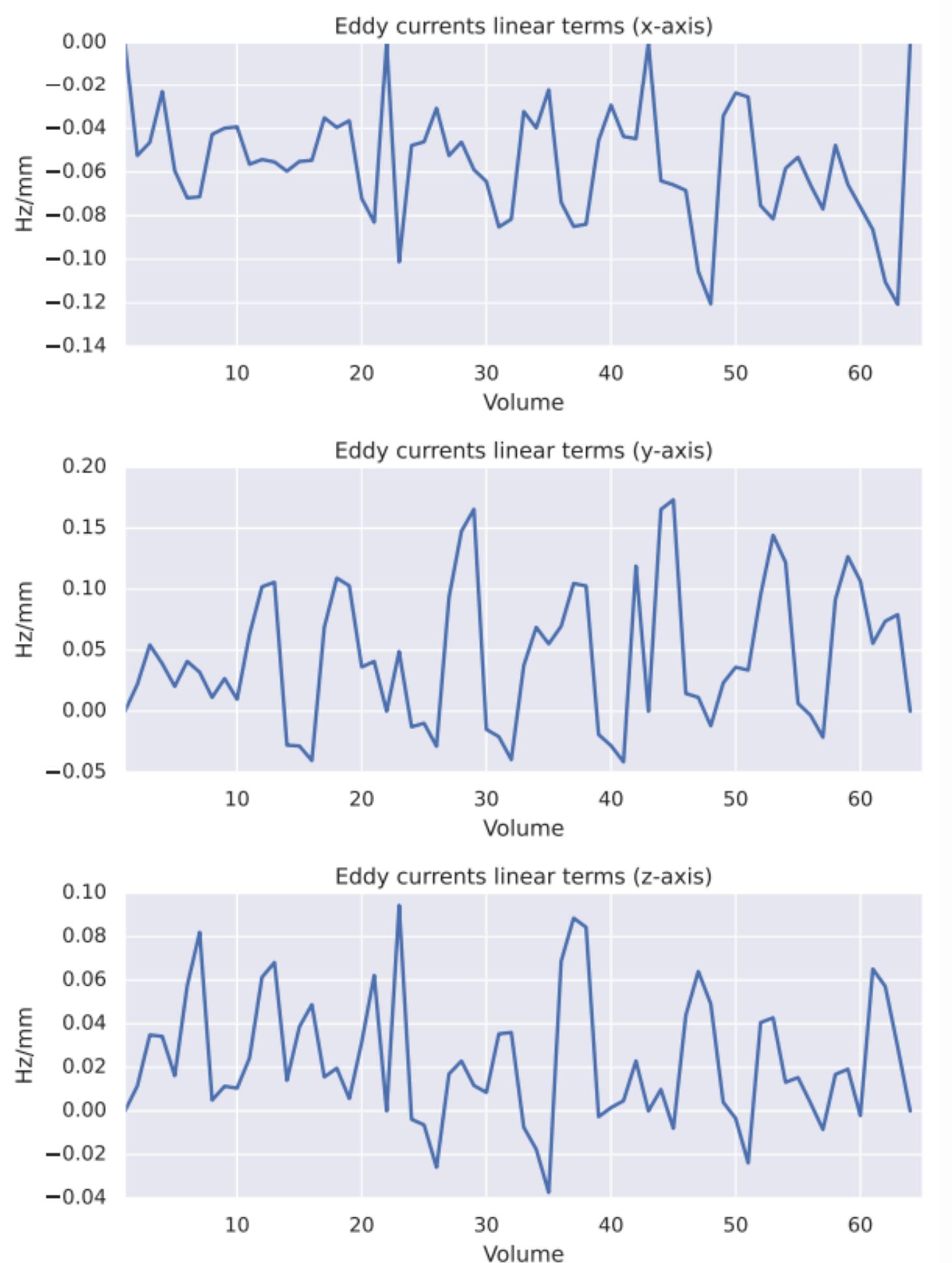
Eddy currents

Std Dev EC linear term (x)	0.03
Std Dev EC linear term (y)	0.06
Std Dev EC linear term (z)	0.03

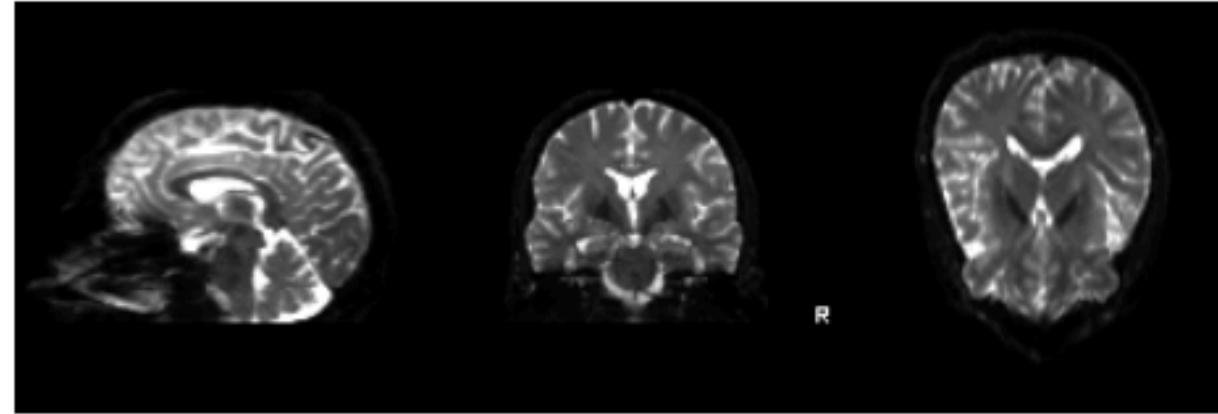
Susceptibility distortions

Std Dev voxel displacement	1.38
----------------------------	------

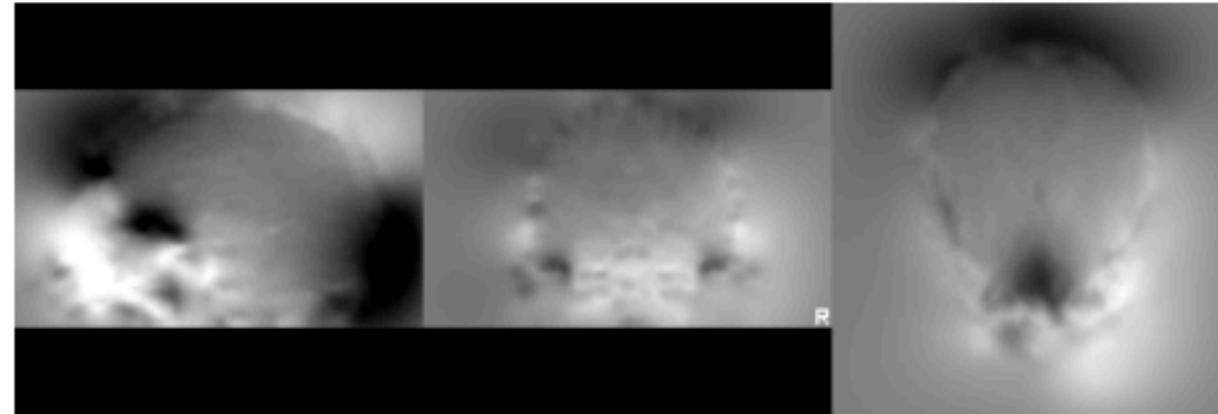




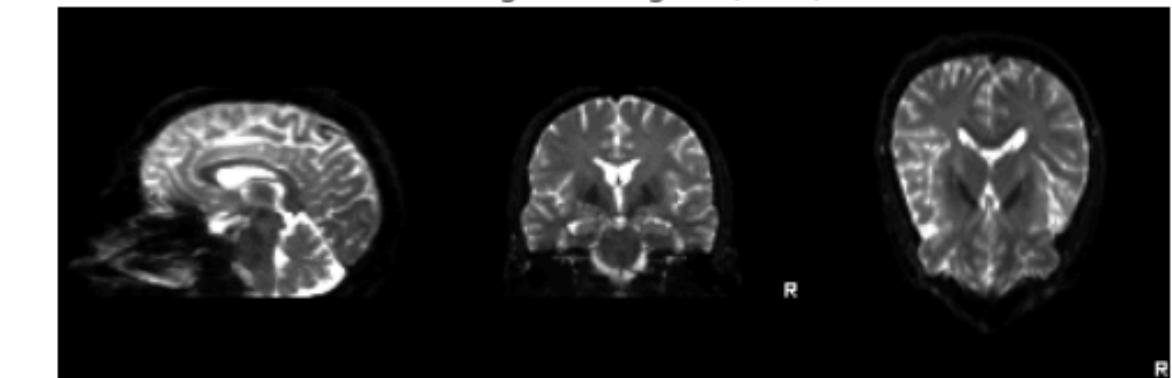
Average b0 signal (PE=[[0. -1. 0.]])



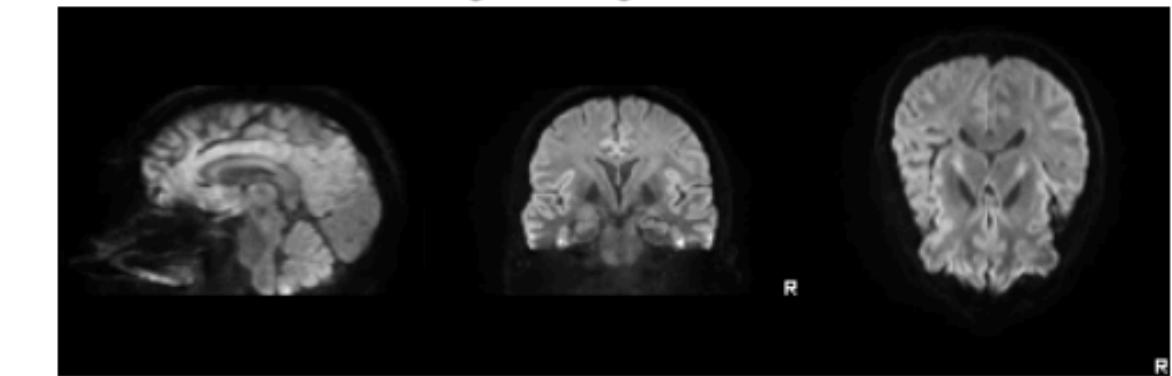
Voxel displacement map



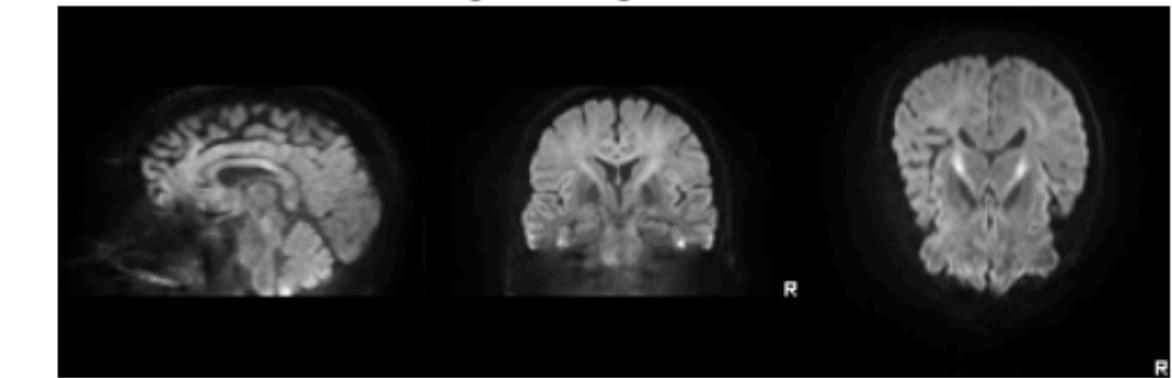
Average DW signal ($b=0$)



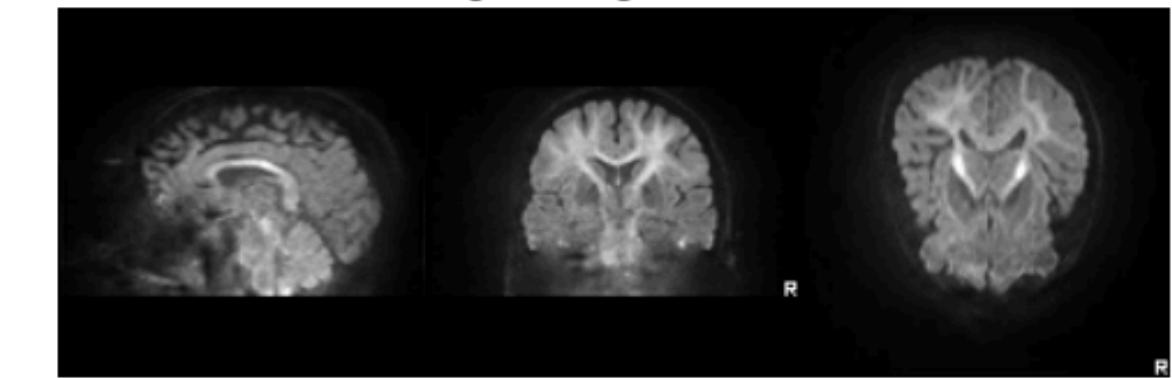
Average DW signal ($b=1000$)

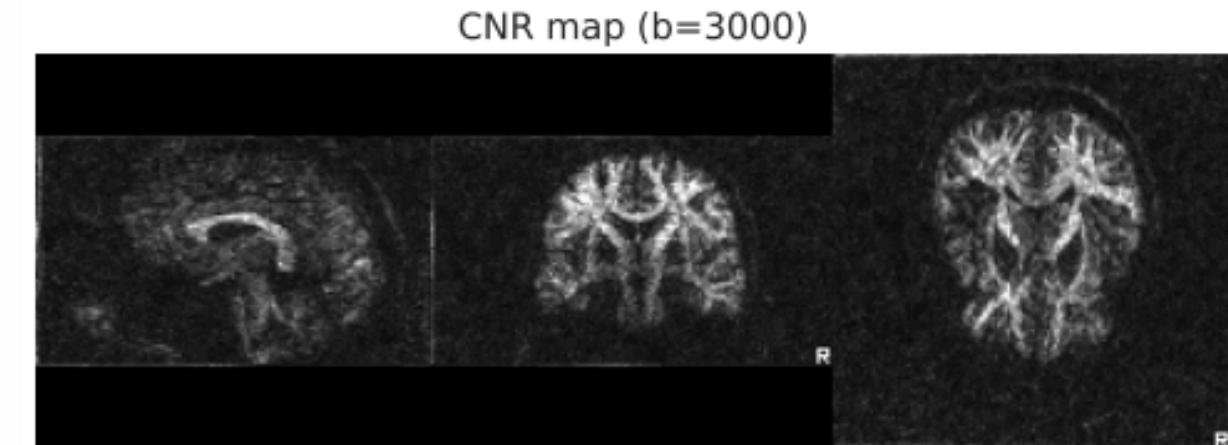
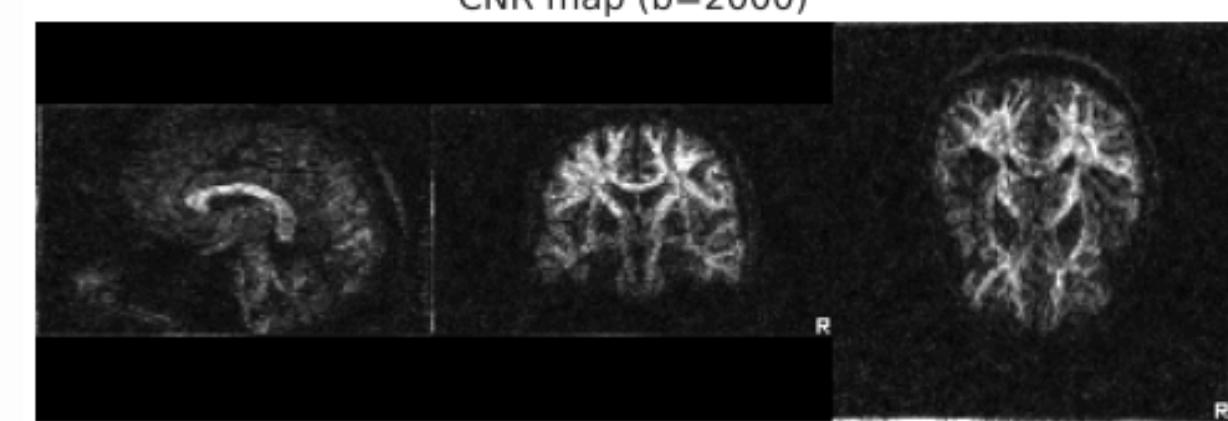
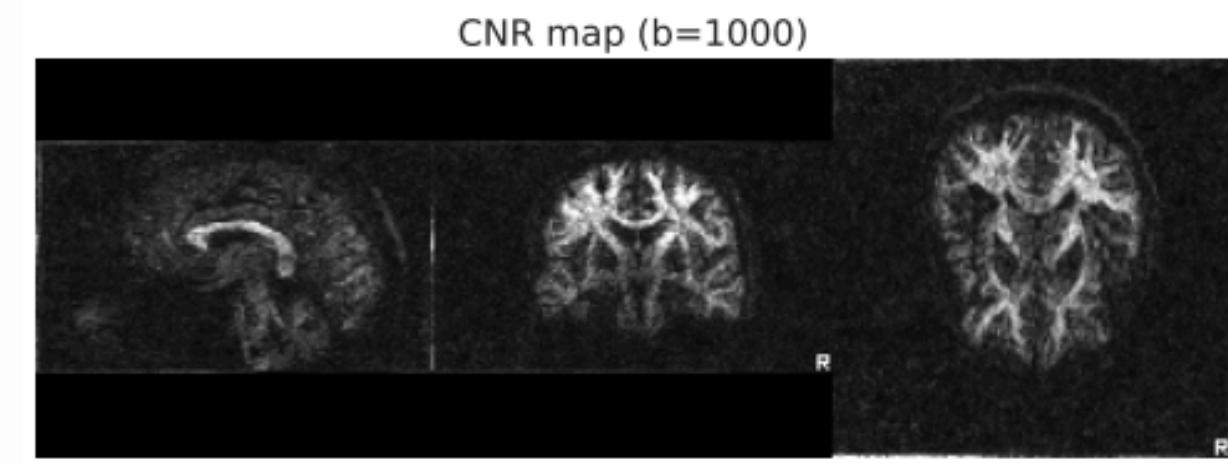
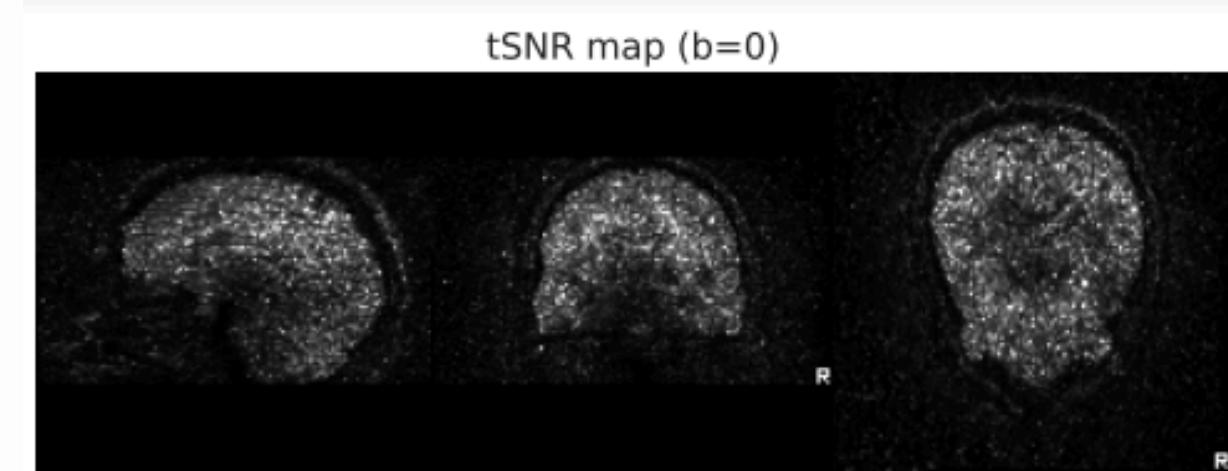
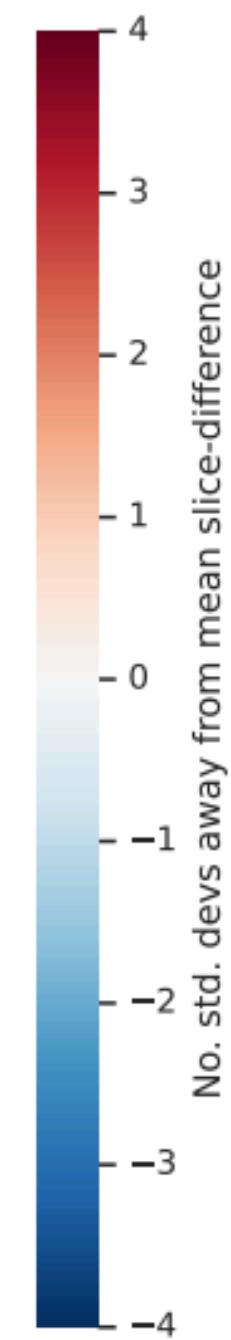
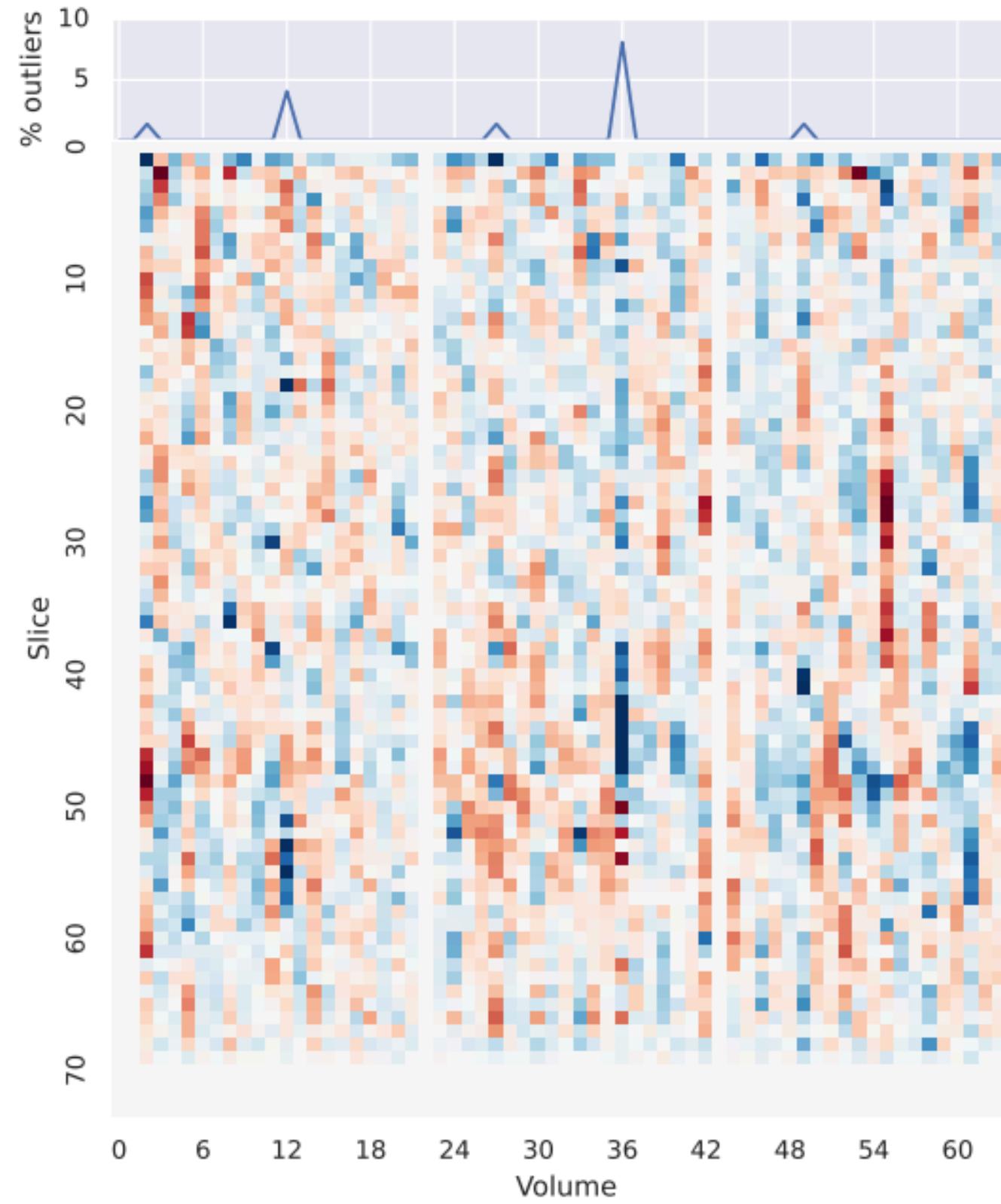
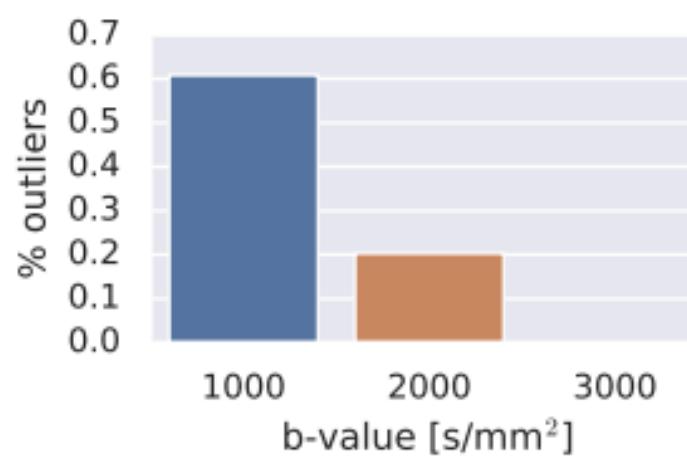
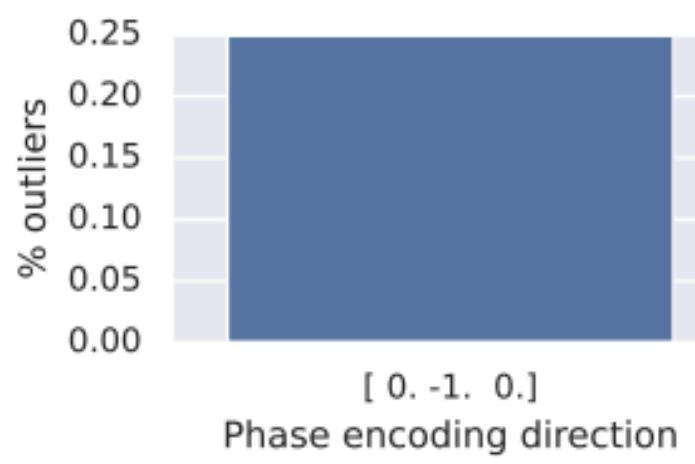


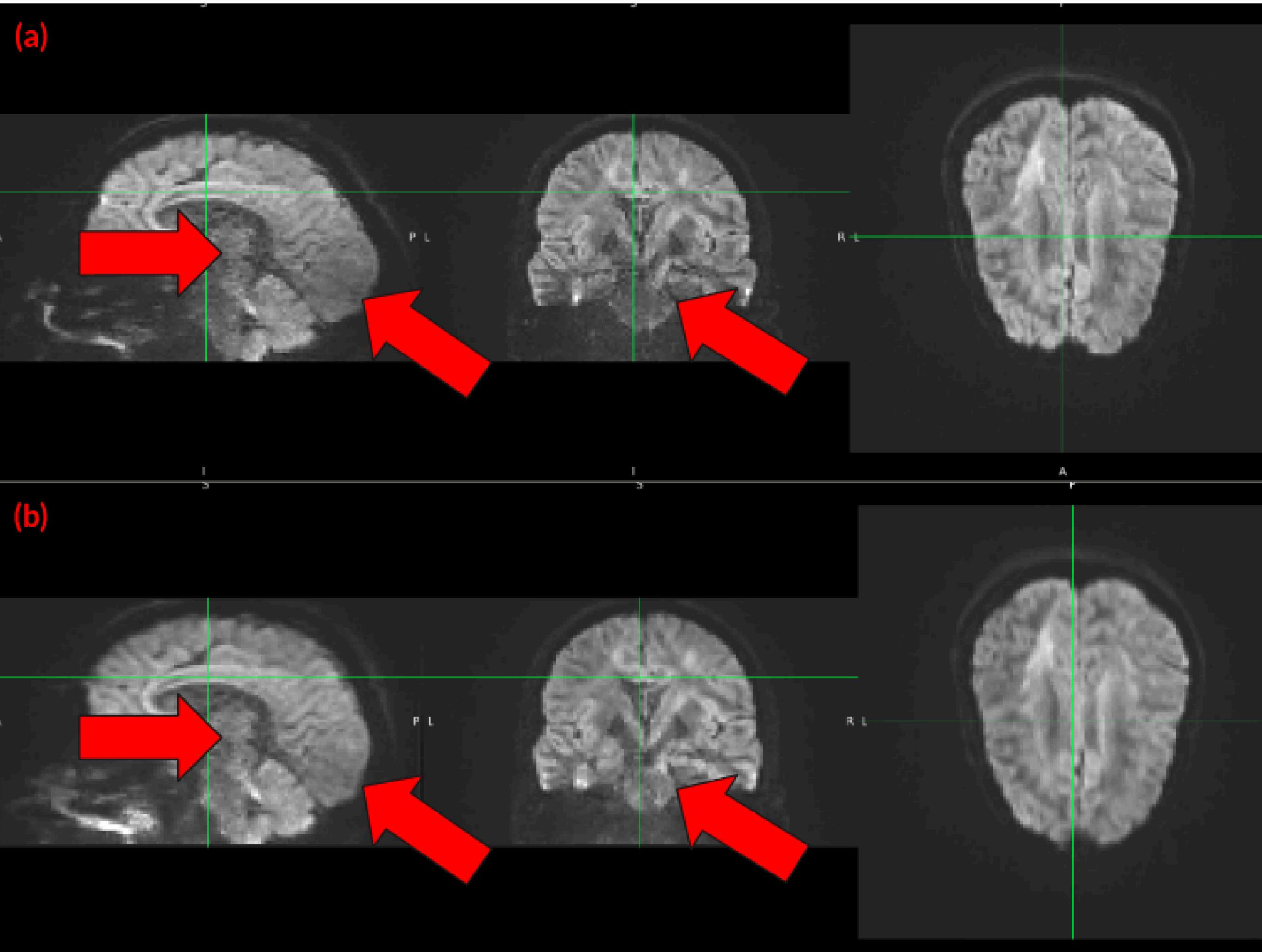
Average DW signal ($b=2000$)



Average DW signal ($b=3000$)







5

dMRI_pipeline_posteddy.sh

QC checkpoint: checks
corregistration between
T1W data and b0

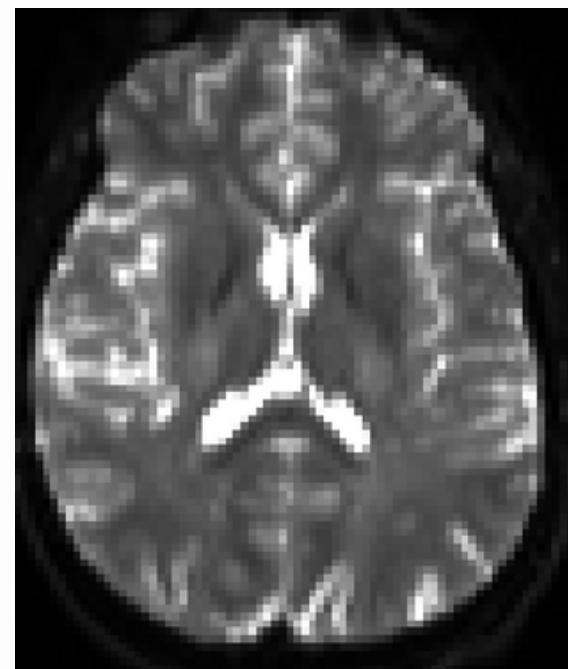
```
[ulsan:x86_64-Linux-MRI-team]...ra.perez/DWI_Ai$>/neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/scripts/dMRI_pipeline_posteddy.sh 010888 /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/010888 /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/data_tracking.csv /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/010888/Preproc_files/Eddy/010888_eddy.qc/outlier_vols.txt
```

```
[alejandra.perezyanez@hanyang:x86_64-Linux]...n/Preproc_files$>ls  
010888_aveb0_brain.nii.gz 010888_DWI_QCd.bvec 010888_T1W_to_b0.nii.gz  
010888_aveb0.mif 010888_DWI_QCd.bvecs 010888_unbiased_bet_brain_mask.nii.gz  
010888_aveb0.nii.gz 010888_DWI_QCd.mif Eddy/  
010888_brain_mask.mif 010888_DWI_QCd.nii.gz FAST/  
010888_DWI_QCd.bval 010888_T1W_to_b0.mif PreEddy/
```

If artefactual volumes
exist, the files are created

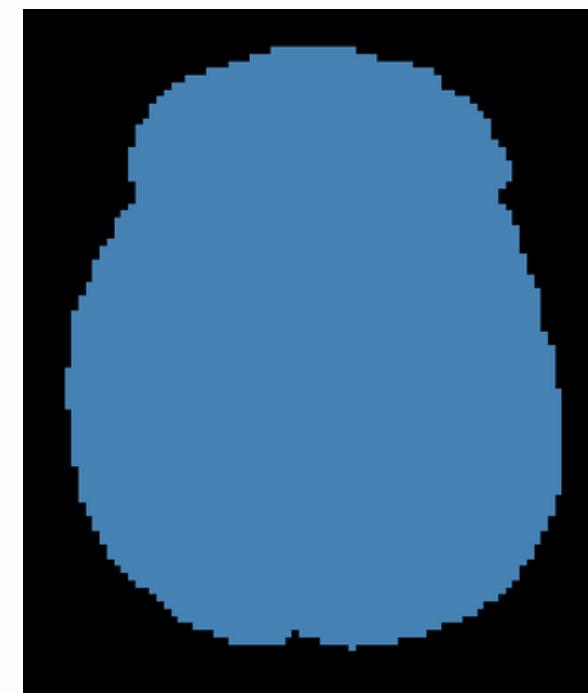
010888_aveb0.nii.gz

b0 file



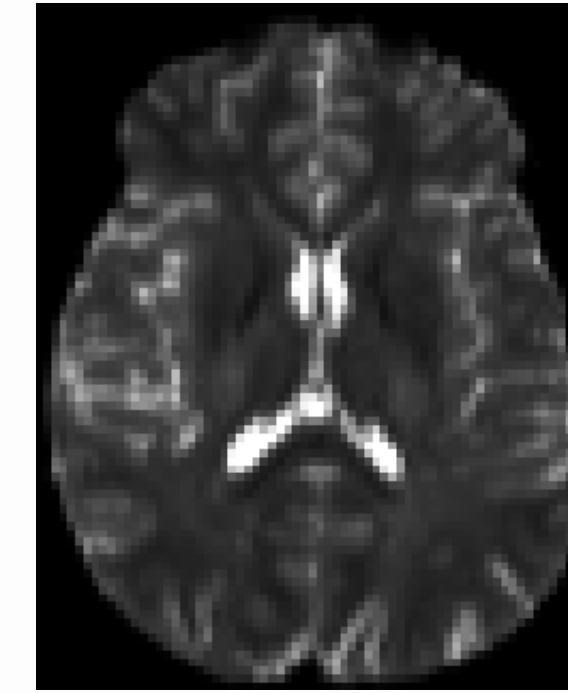
010888_brain_mask.mif

Brain mask in post-QC



010888_aveb0_brain.nii.gz

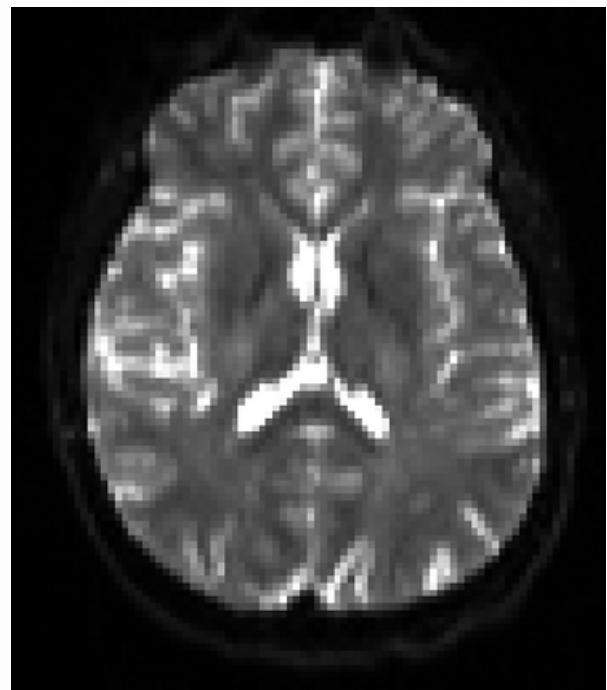
aveb0 with brain mask applied



010888_DWI_QCd.mif

010888_DWI_QCd.nii.gz

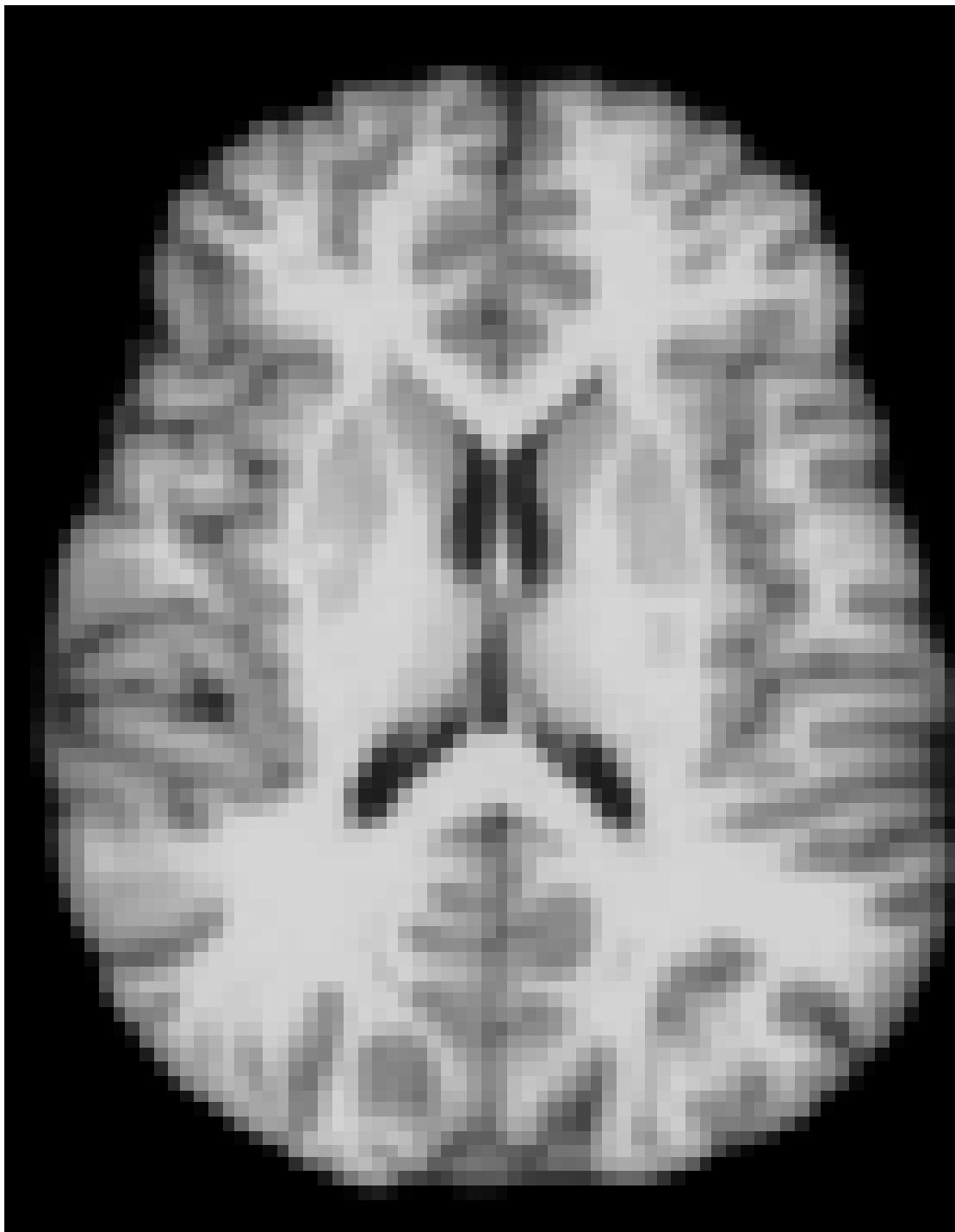
Processed and QC'd
final DWI volume



MASK: Single volume image file with ones and zeros specifying
brain (one) and no-brain (zero).

T1 brain image in b0 space:
alignment of T1W image with the
b0 image

010888_T1W_to_b0.nii.gz



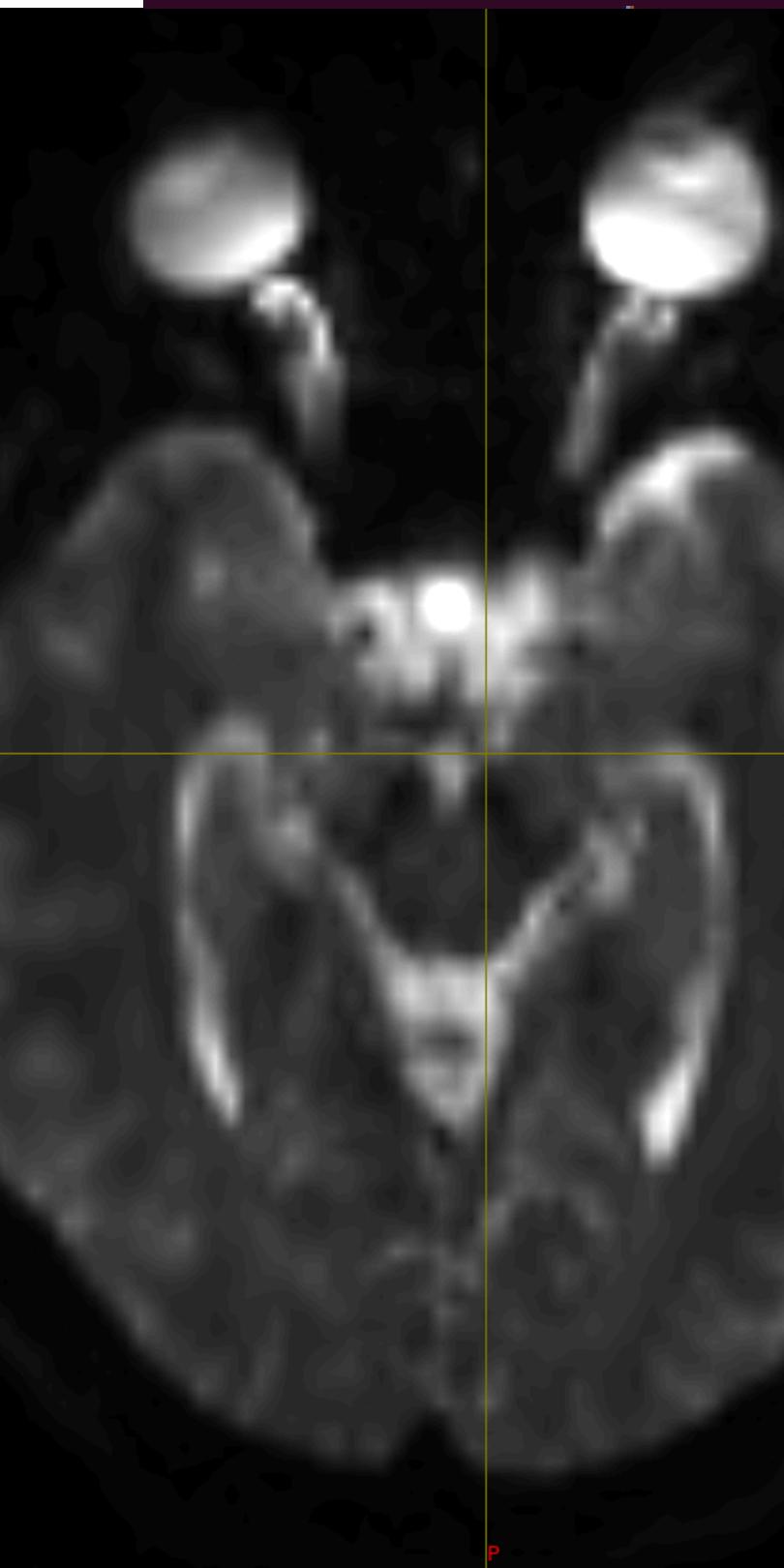
010888_T1W_to_b0.mif



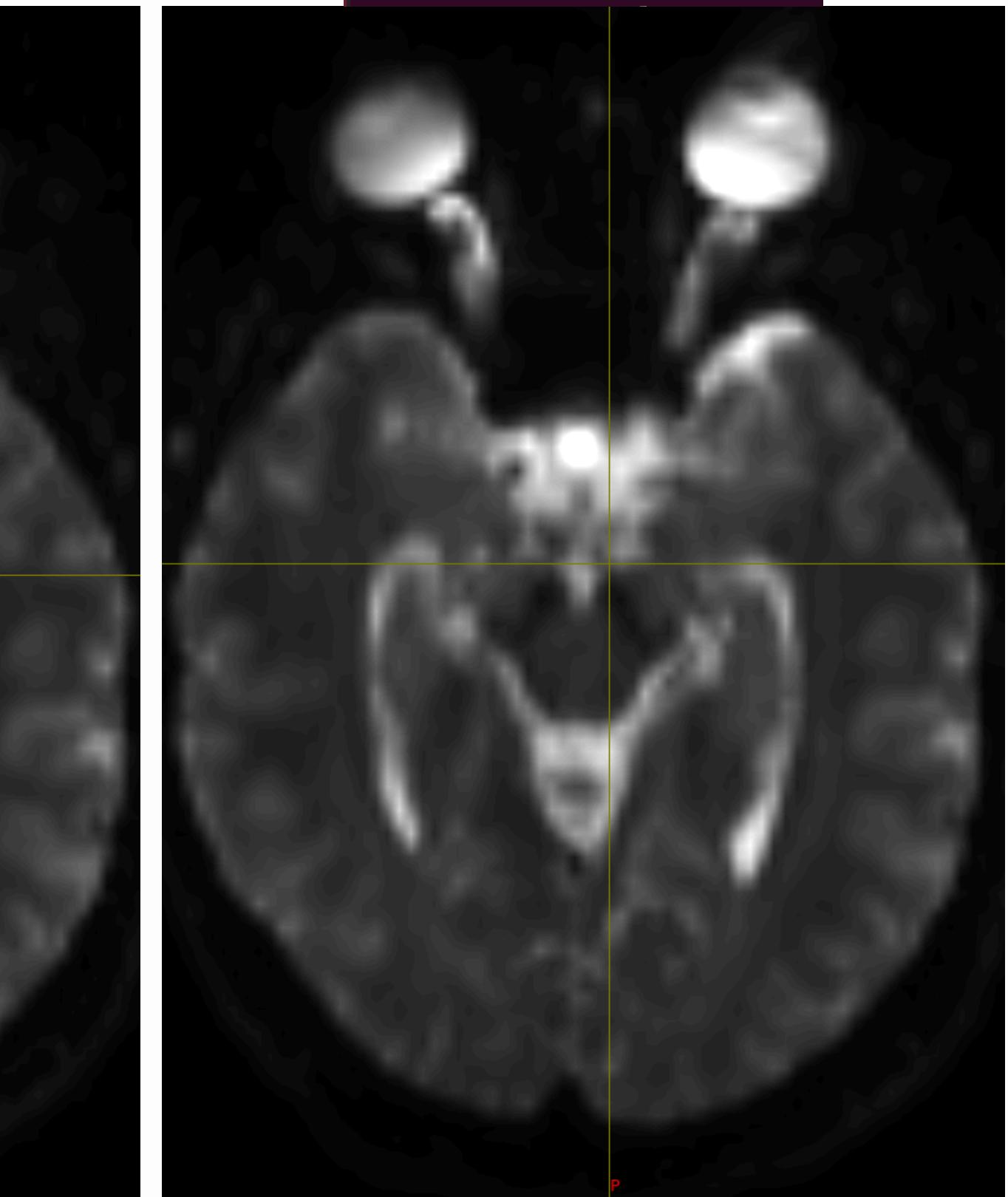
010888_DWI_QCd.bval | 010888_DWI_QCd.bvec

0.00	0.0000000	0.0000000	0.0000000
0.00	0.2237458	0.0073275	-0.9746200
2000.00	0.2246651	0.0025423	-0.9744327
3000.00	-0.2836833	-0.2683894	-0.9205927
1000.00	-0.2813217	-0.2651890	-0.9222434
2000.00	-0.2810962	-0.2625784	-0.9230588
3000.00	0.0457355	0.4925058	-0.8691066
1000.00	0.0442192	0.4896363	-0.8708048
2000.00	0.0465421	0.4871586	-0.8720724
3000.00	0.3435711	-0.4630221	-0.8170492
1000.00	0.3432651	-0.4573650	-0.8203574
2000.00	-0.6256368	0.1228082	-0.7703874
3000.00	-0.6241112	0.1171139	-0.7725086
1000.00	-0.6225211	0.1183043	-0.7736095
2000.00	0.5883609	0.3751117	-0.7163258
3000.00	0.5861773	0.3741389	-0.7186211
1000.00	0.5874523	0.3697294	-0.7198610
2000.00	-0.1970552	-0.7212599	-0.6640432
3000.00	-0.1933527	-0.7191367	-0.6674258
0.00	0.0000000	0.0000000	0.0000000
3000.00	-0.1957772	-0.7170694	-0.6689415
1000.00	-0.3549763	0.7047274	-0.6142891
2000.00	-0.3569031	0.7009949	-0.6174353
3000.00	-0.3528807	0.7003974	-0.6204181
2000.00	0.7697378	-0.2916714	-0.5678306
3000.00	0.7688652	-0.2926459	-0.5685109
1000.00	-0.7919097	-0.3274690	-0.5154058
2000.00	-0.7893381	-0.3281295	-0.5189185
3000.00	-0.7898532	-0.3248250	-0.5202121
1000.00	0.3802668	0.8015453	-0.4614350
2000.00	0.3770028	0.8009653	-0.4651058
3000.00	0.3810340	0.7972905	-0.4681249
2000.00	0.2698932	-0.8685682	-0.4156283
3000.00	0.2661698	-0.8692138	-0.4166786
1000.00	-0.7991453	0.4785335	-0.3638303
2000.00	-0.8003270	0.4731169	-0.3682894
3000.00	-0.7986141	0.4743597	-0.3704030
1000.00	0.9273485	0.2063441	-0.3121649
0.00	0.0000000	0.0000000	0.0000000
2000.00	0.9260361	0.2070644	-0.3155653
3000.00	0.9268965	0.2018578	-0.3164116
2000.00	-0.5565230	-0.7877907	-0.2639470
3000.00	-0.5533351	-0.7884414	-0.2686640
2000.00	-0.5555089	-0.7867038	-0.2692712
3000.00	-0.1227439	0.9694358	-0.2124340
1000.00	-0.1189821	0.9690107	-0.2164754
2000.00	0.7469100	-0.6442069	-0.1646901
3000.00	0.7497881	-0.6398634	-0.1685011
1000.00	0.7467502	-0.6438154	-0.1669310
2000.00	-0.9926236	-0.0433588	-0.1132182
3000.00	-0.9920722	-0.0445900	-0.1174926
1000.00	-0.9920132	-0.0398395	-0.1196772
2000.00	0.7075042	0.7042145	-0.0593277

010888_DWI_QCd.mif



010888_aveb0.mif



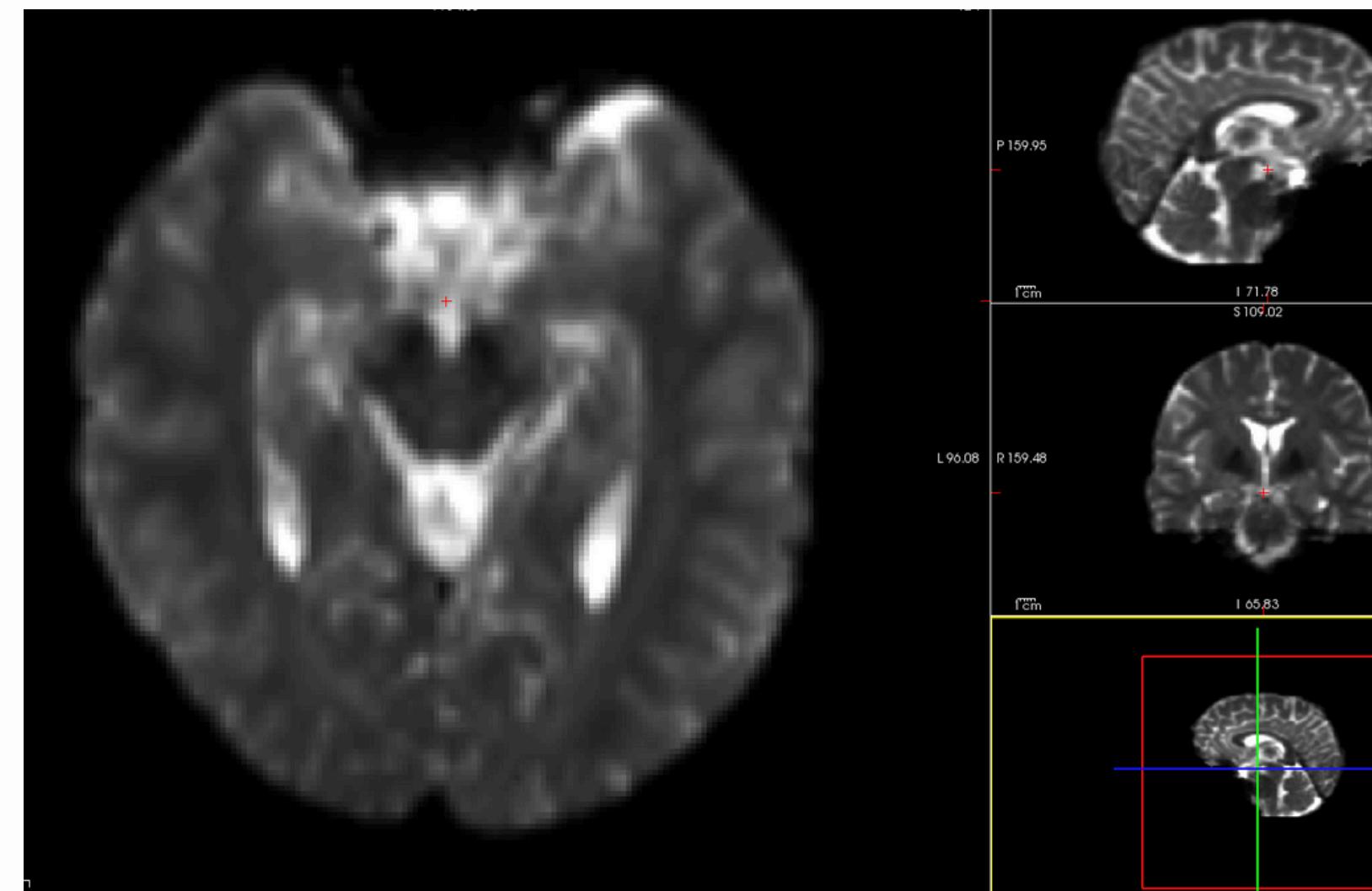
Transforms directory is created

```
(dMRI_env) [ulsan:x86_64-Linux-MRI-team]...n/Preproc_files$>ls ..(Transforms/  
flirt_aveb0_to_T1W_initial.mat  flirt_aveb0_to_T1W_inv.mat  flirt_aveb0_to_T1W.mat  flirt_aveb0_to_T1W.nii.gz
```

flirt_aveb0_to_T1W_initial.mat flirt_aveb0_to_T1W_inv.mat

flirt_aveb0_to_T1W.txt flirt_aveb0_to_T1W transformation
matrix

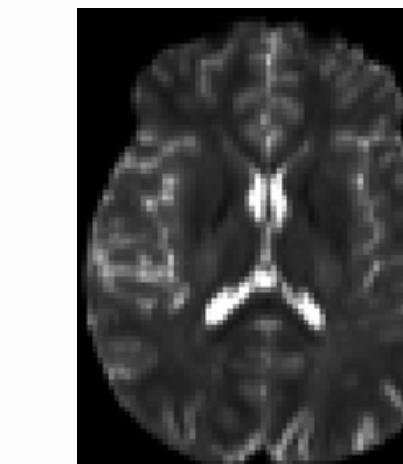
```
0.999990018246694 0.00155021885120594 0.00419553030010708 -0.22852121622743  
-0.00158168051062652 0.99997058288421 0.0075059601269588 -0.202858419057614  
-0.00418377097854186 -0.0075125206717162 0.999962984421257 0.558699560717846  
0 0 0 1
```



flirt_aveb0_to_T1W.nii.gz

010888_aveb0_brain.nii.gz

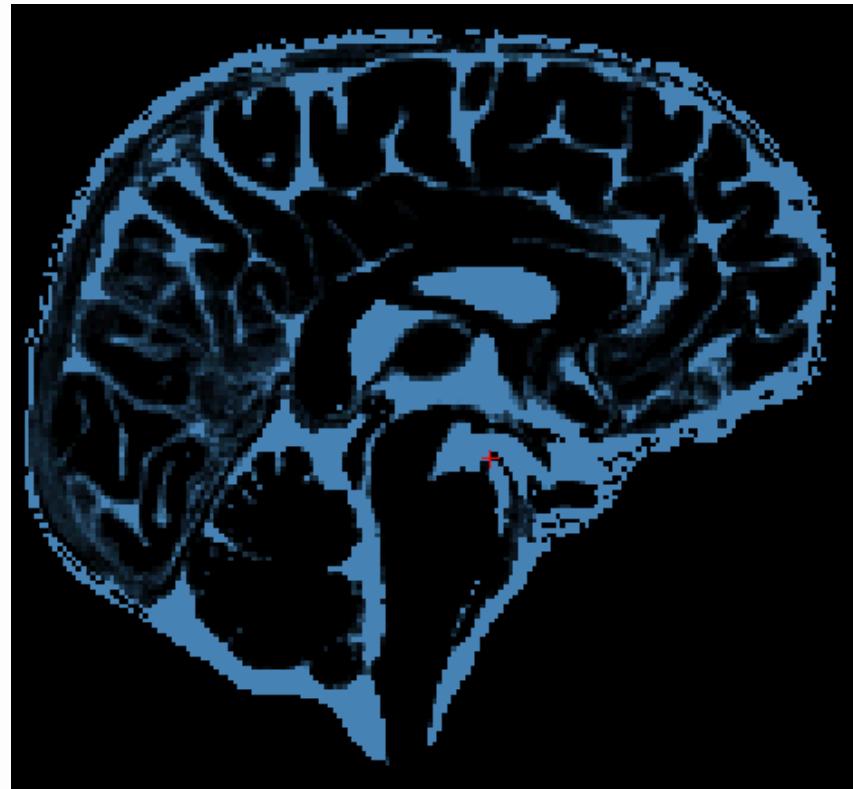
aveb0 with brain mask applied ->T1W_brain image



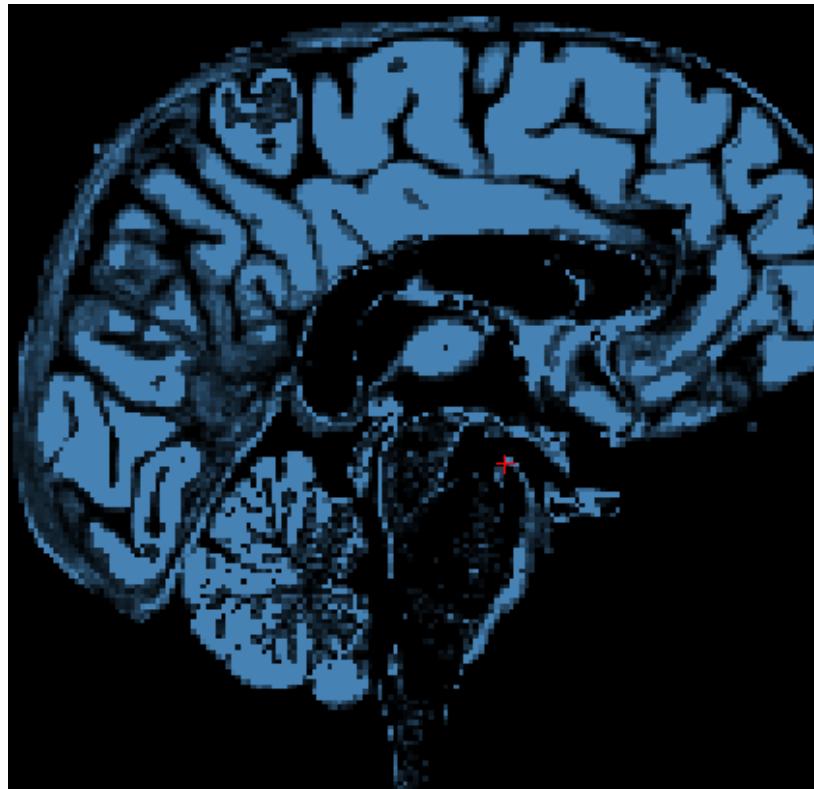
FAST directory is created

```
(dMRI_env) [ulsan:x86_64-Linux-MRI-team]...n/Preproc_files$>ls FAST/  
010888_fast_mixeltype.nii.gz 010888_fast_pve_1.nii.gz 010888_fast_pveseg.nii.gz 010888_fast_seg_1.nii.gz 010888_fast_seg.nii.gz  
010888_fast_pve_0.nii.gz      010888_fast_pve_2.nii.gz 010888_fast_seg_0.nii.gz    010888_fast_seg_2.nii.gz
```

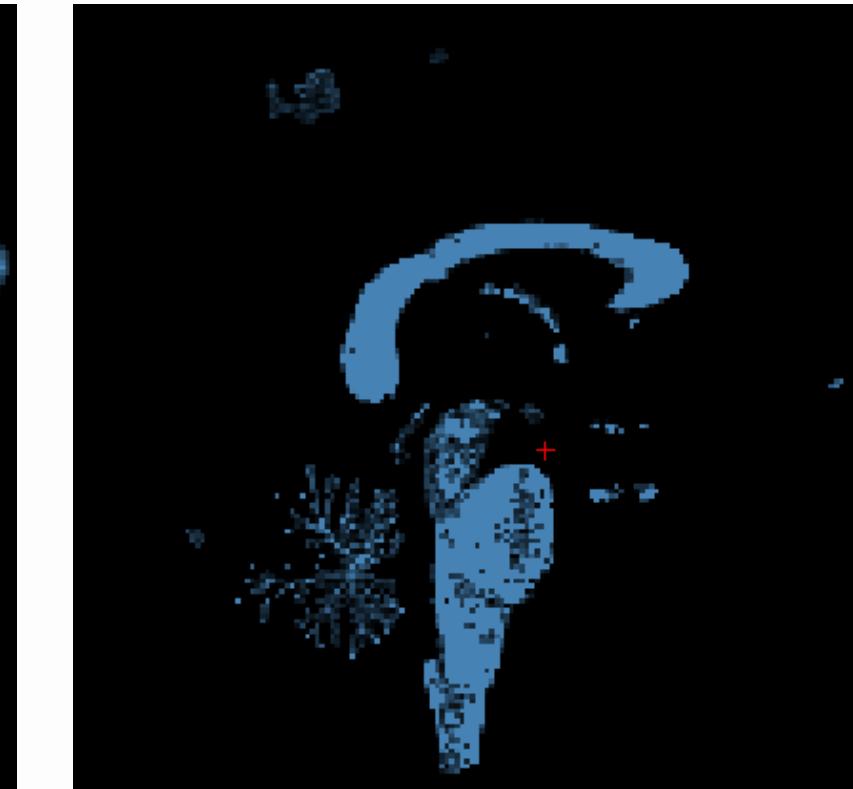
010888_fast_pve_0.nii.gz



010888_fast_pve_1.nii.gz



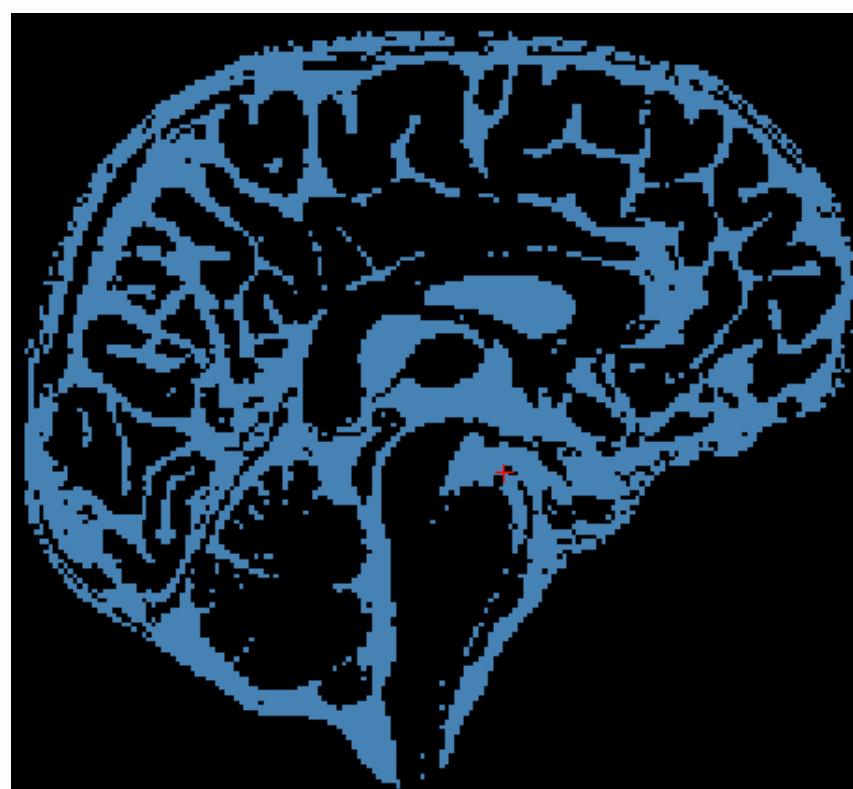
010888_fast_pve_2.nii.gz



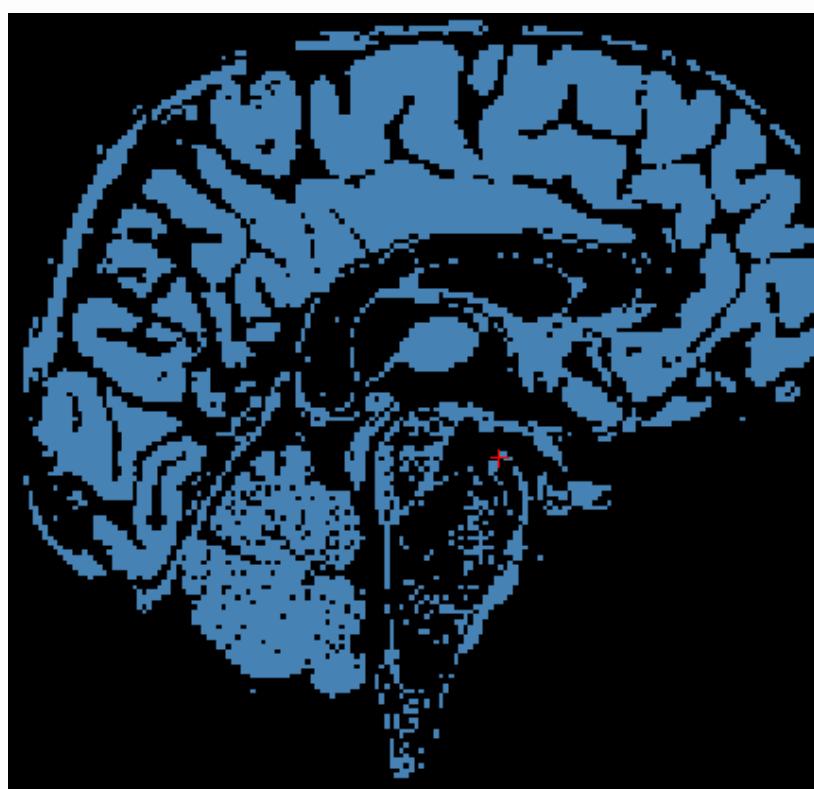
010888_fast_pveseg.nii.gz



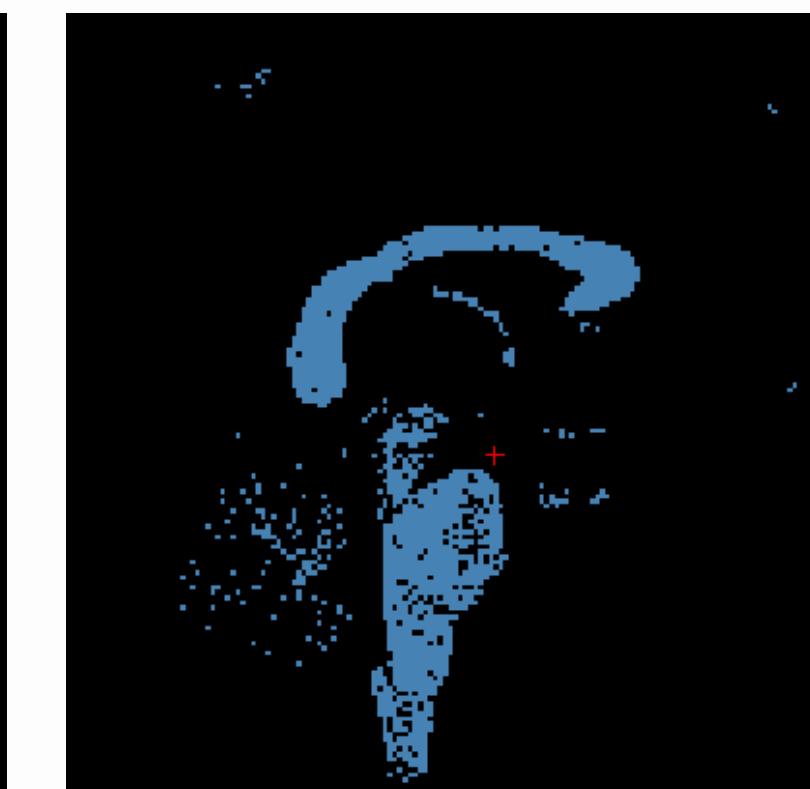
010888_fast_seg_0.nii.gz



010888_fast_seg_1.nii.gz



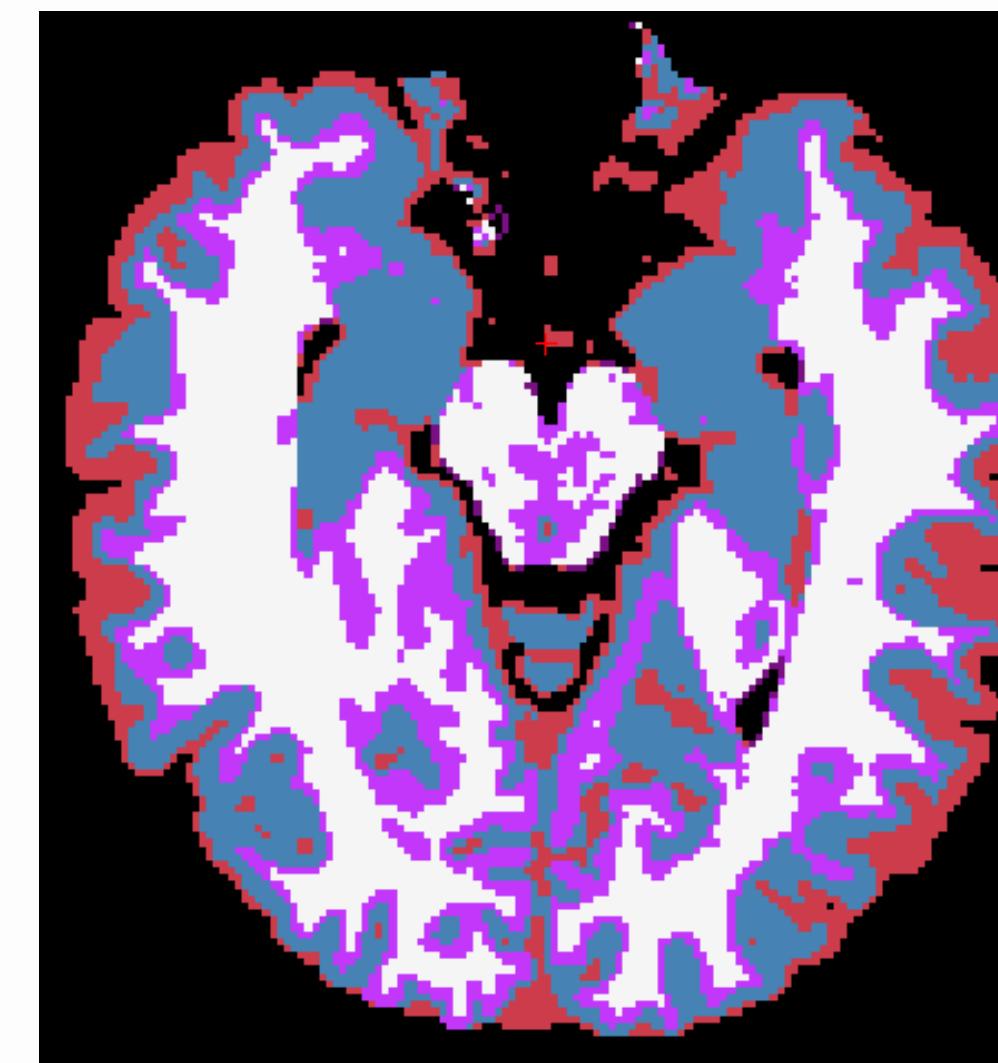
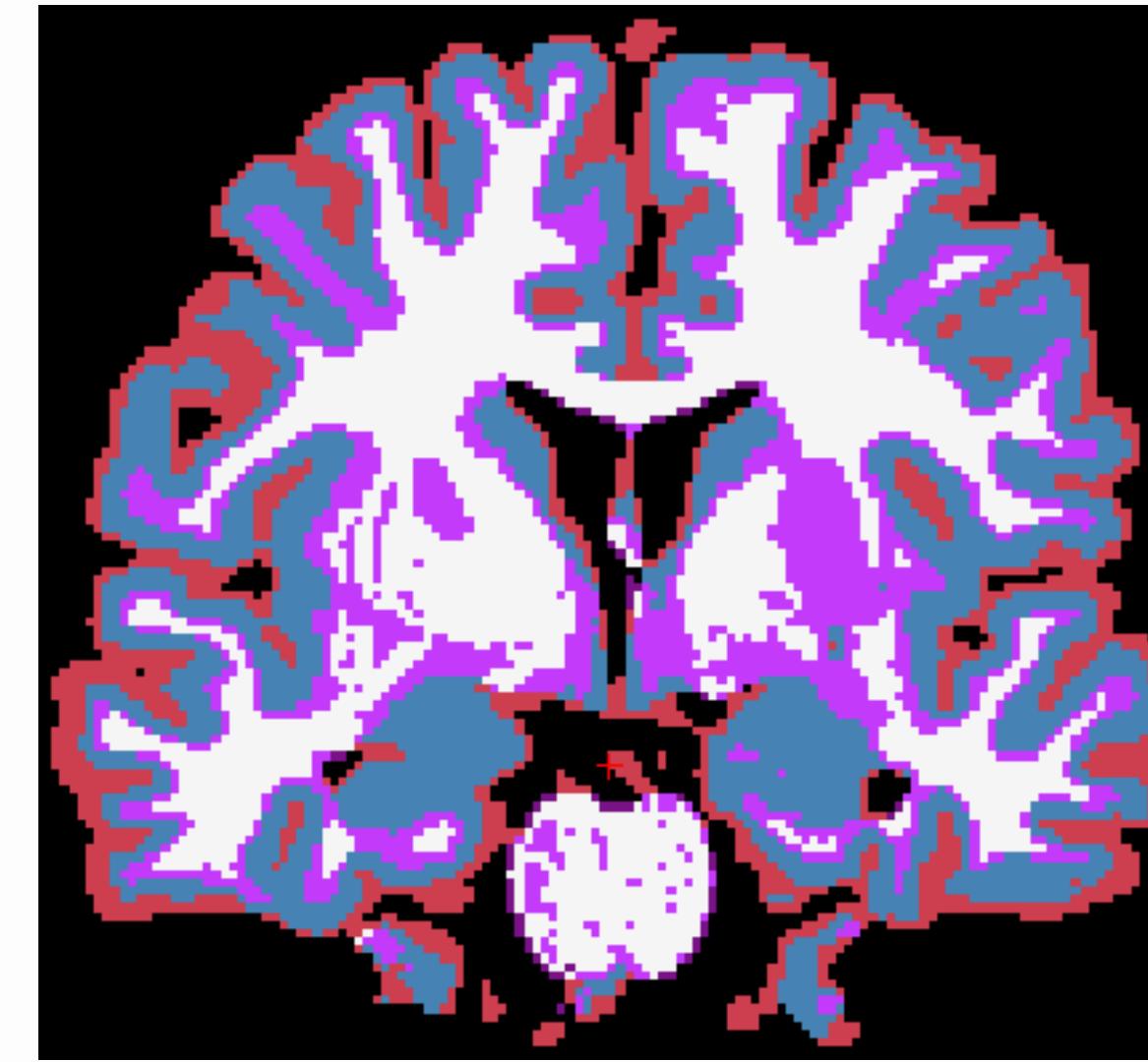
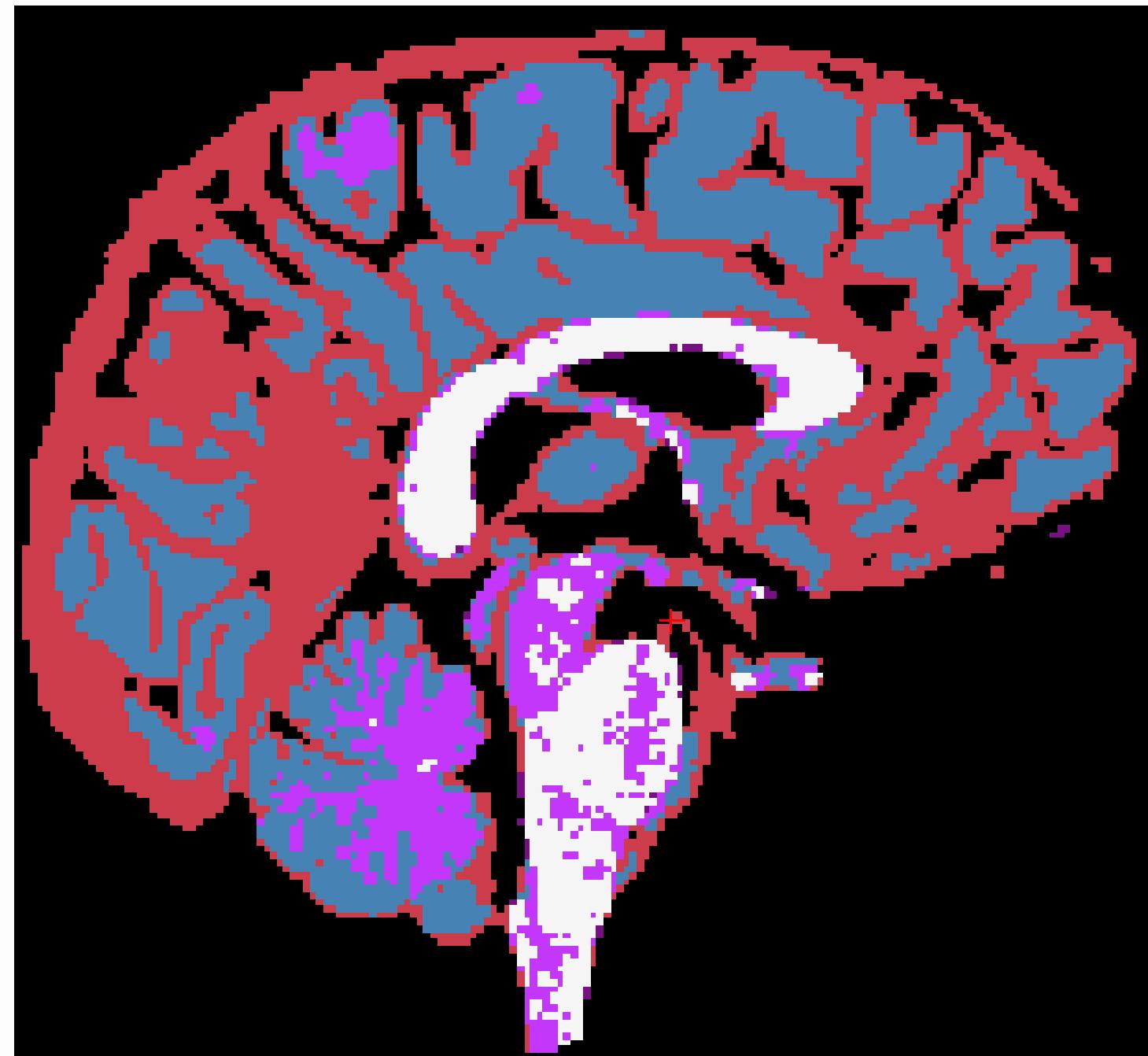
010888_fast_seg_2.nii.gz



010888_fast_seg.nii.gz



010888_fast_mixeltype.nii.gz



- 1 Left-Cerebral-Exterior
- 2 Left-Cerebral-White-Matter
- 3 Left-Cerebral-Cortex
- 4 Left-Lateral-Ventricle
- 5 Left-Inf-Lat-Vent

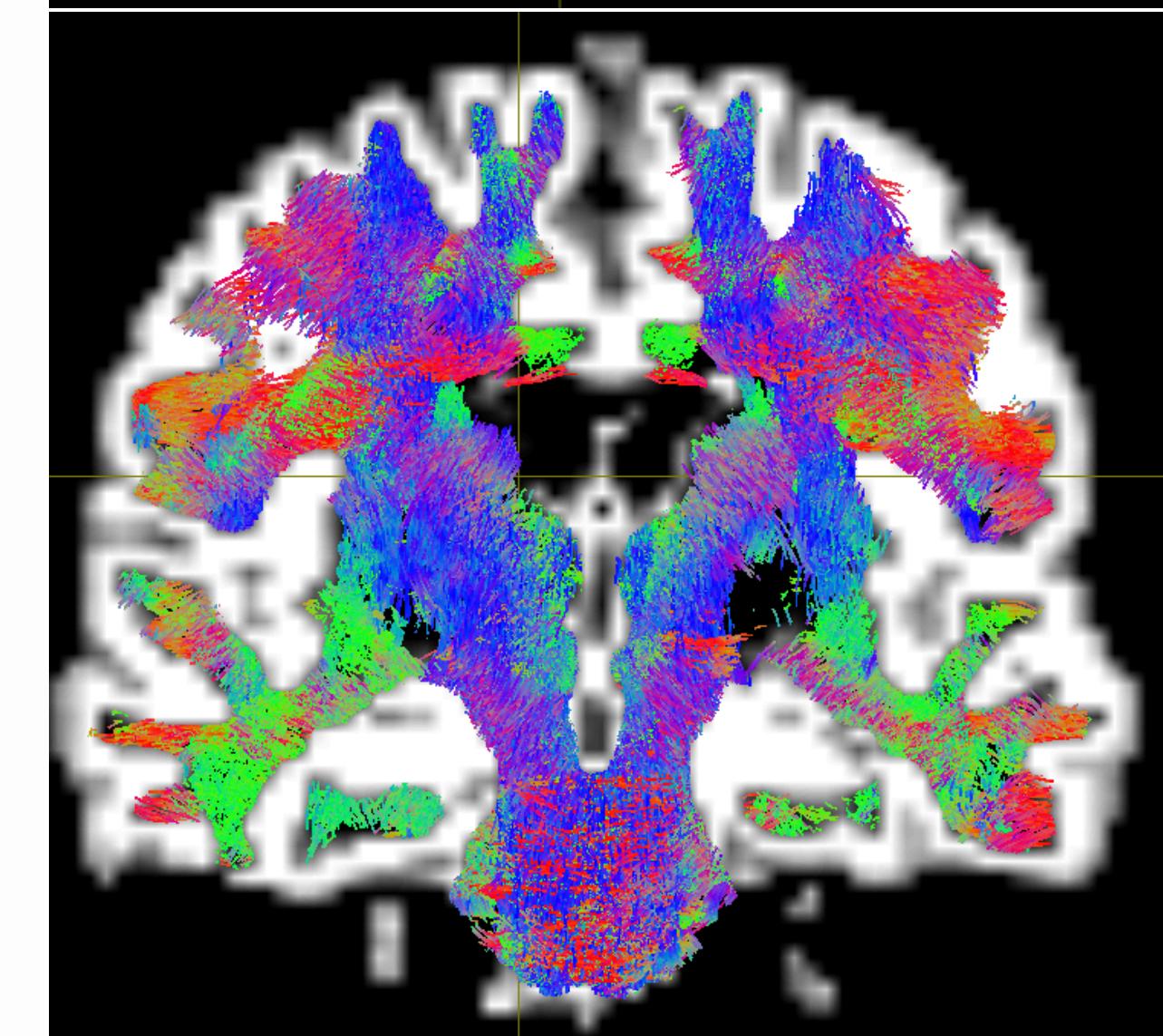
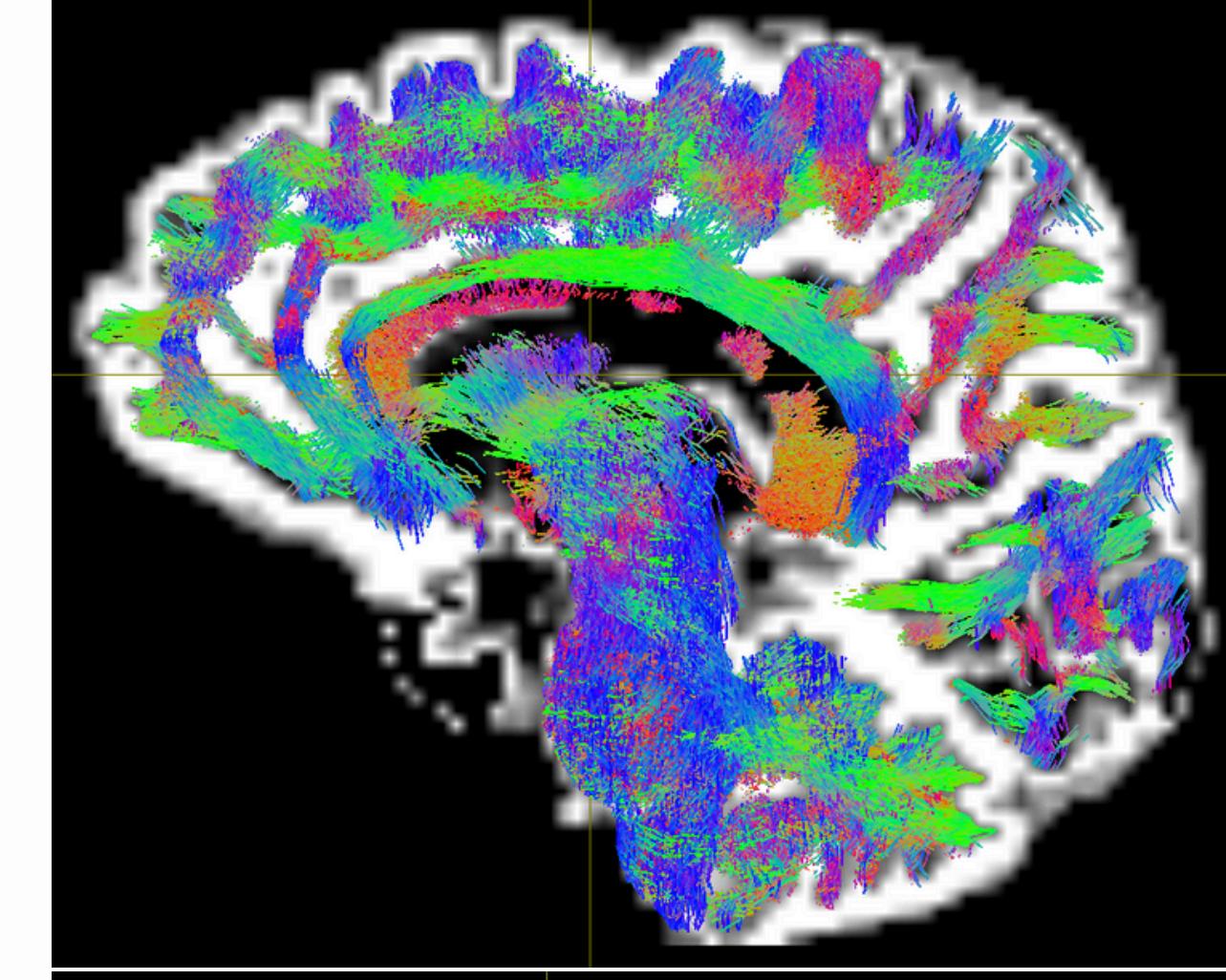
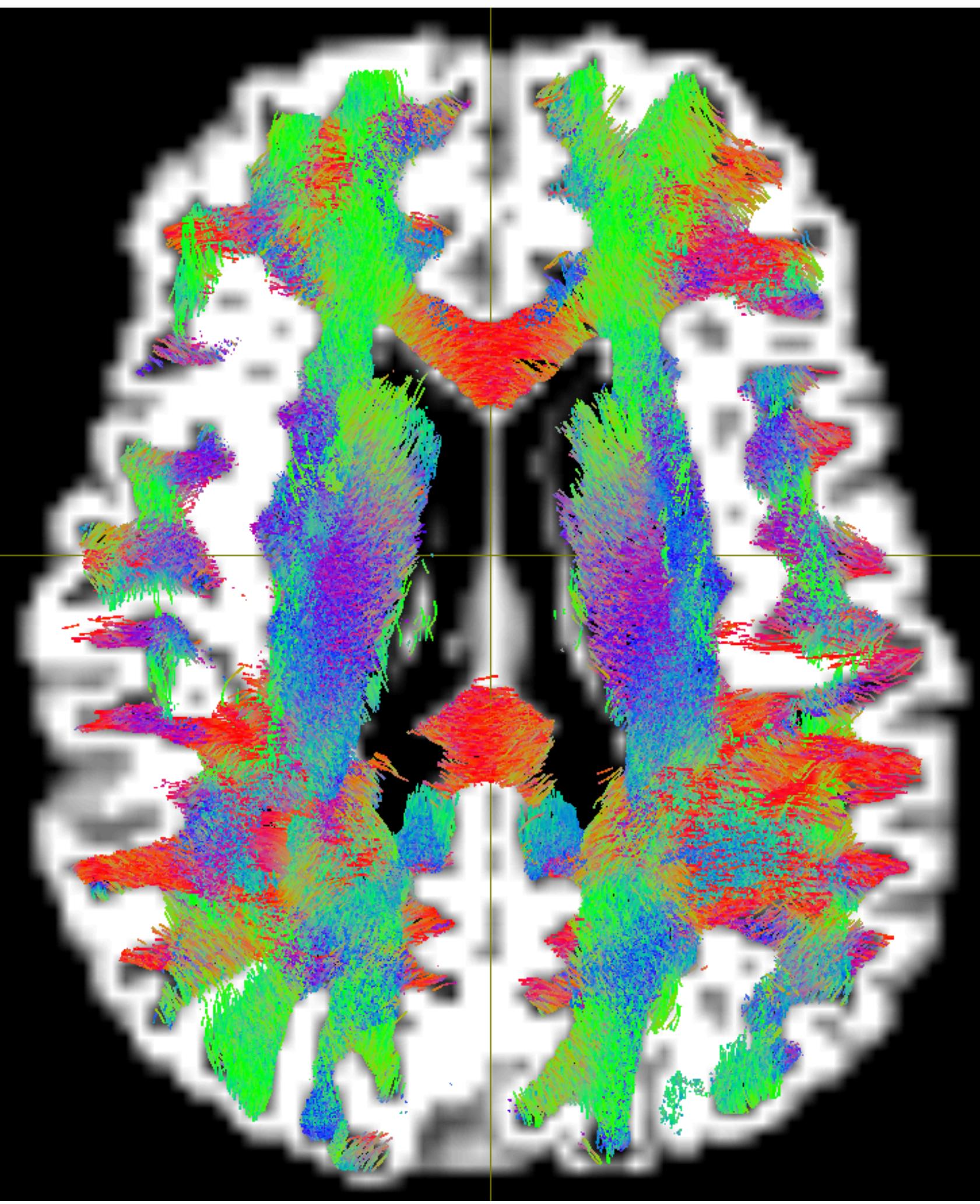
6

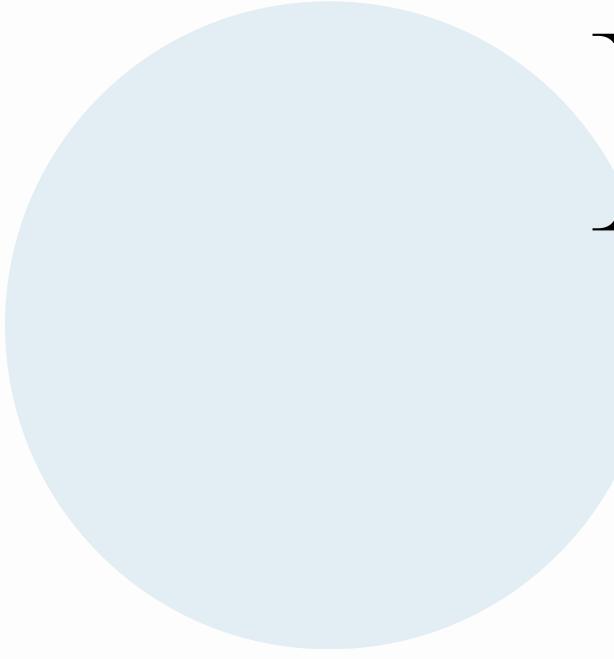
dMRI_pipeline_coregAtlas.sh

```
(dMRI_env) [ulsan:x86_64-Linux-MRI-team]...ra.perez/DWI_Ai$>/neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/scripts/dMRI_pipeline_coregAtlas.sh 010888 /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/010888/Diffusion/Preproc_files/010888_aveb0_brain.nii.gz /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/010888/Freesurfer/mri/brain.nii.gz /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/010888/Diffusion/Transforms/flirt_aveb0_to_T1W.mat /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/010888/Freesurfer/mri/aparc+aseg.mgz /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/FreeSurferColorLUT.txt /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/fs_default.txt /neuro/labs/grantlab/research/MRI_processing/alejandra.perez/DWI_Ai/010888/Diffusion/Atlases/atlas_coreg_Freesurfer
```

```
(dMRI_env) [ulsan:x86_64-Linux-MRI-team]...ffusion/Atlases$>ls atlas_coreg_Freesurfer/  
010888_aparc.a2009s+aseg_to_b0_nodes.mif aparc.a2009s+aseg.mif aparc+aseg.mif aparc+aseg_to_b0_nodes.mif fs_bilateral/  
010888_aparc+aseg_to_b0_nodes.mif aparc.a2009s+aseg_to_b0_nodes.mif aparc+aseg.nii.gz Atlases/ fs_roi_mask.nii.gz  
(dMRI_env) [ulsan:x86_64-Linux-MRI-team]...ffusion/Atlases$>ls atlas_coreg_Freesurfer/Atlases/  
aparc+aseg.mif aparc+aseg_to_b0_nodes.mif
```

Converts and inverts b0->T1W transform from FSL to MRtrix format and applies to an atlas. Atlas is then relabelled for MRtrix.





References

- [4] <https://www.sciencefacts.net/eddy-current.html>
 - [5] https://web.stanford.edu/class/rad229/Notes/Lecture-05/Rad229_2020_Lecture05B_Imperfections_I_Eddy_Currents.pdf
 - [6] [Connectome analysis: Characterization, methods and analysis](#)
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