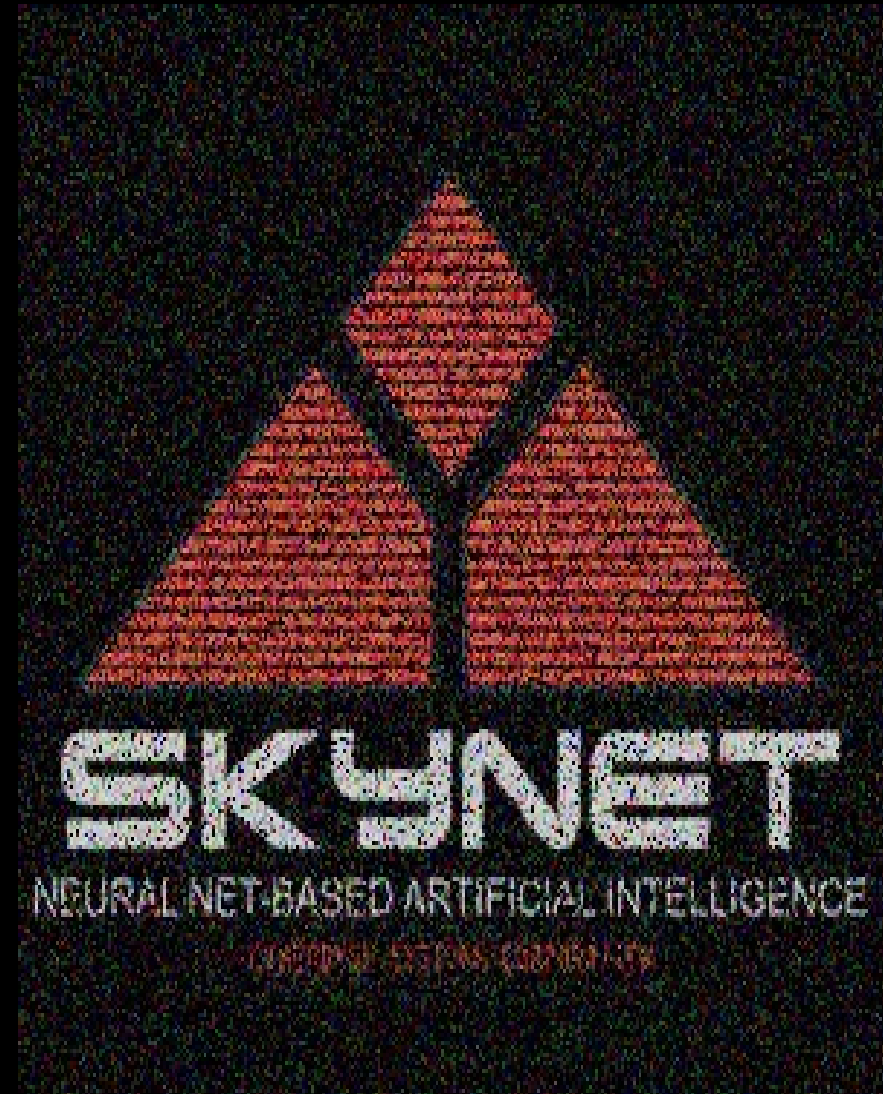


IOWA

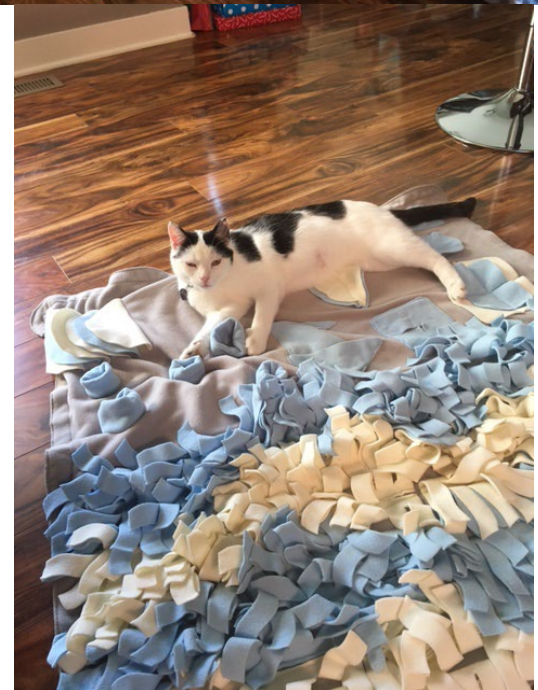
Quality Control & Imaging Gone Wrong

Eric Axelson



Outline

- Pros and cons of automation
- Get your eyes on your data
- Tips, Tricks, and Mantras
- How to do this
- Common imaging issues to look out for
- Crazy stuff and hard cases
- Questions



Pros and Cons of Automation

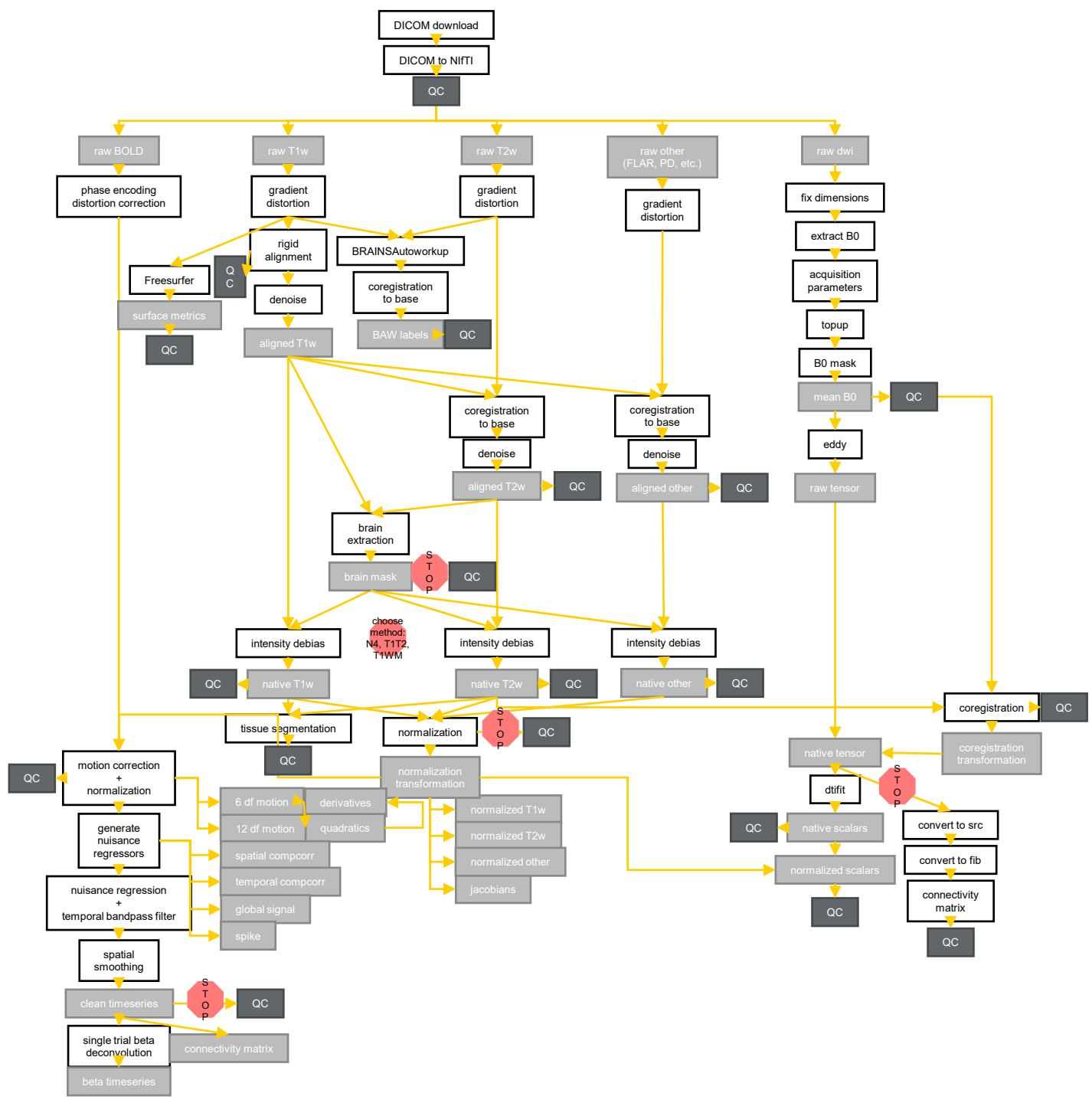
Pros:

- More throughput
- Less user time
- More reliable results
- Human error and drift minimized
- Can ask and answer(?) many more questions

Cons:

- Complexity
- Rarely a one size fits all
- Only as good as the underlying data powering the tool, algorithm, or pipeline
- Expert knowledge superseded
- Compute time increases





Get your eyes on your data



- Need to determine what to QC, how, and the quality metrics
- Its all about compromise: what are you willing to accept
- Looking at your outputs can save you a lot of debugging
- Its easy to generate data but harder to ensure accuracy and precision

Accuracy (validity): The degree to which a measurement represents the true value of something. **Simply put: How close a measurement is to the true value**

Precision (reliability): The degree of resemblance among study results, were the study to be repeated under similar circumstances. **Simply put: How close the measurements are to each other**



Accurate, reliable



Accurate, unreliable



Inaccurate, reliable



Inaccurate, unreliable

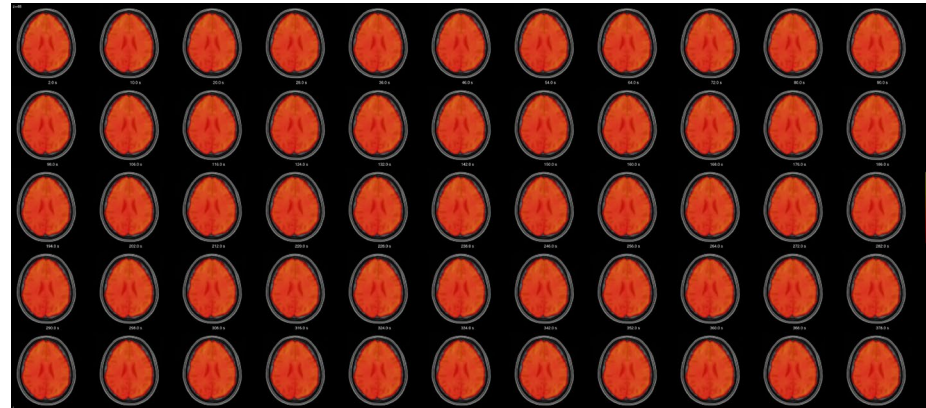
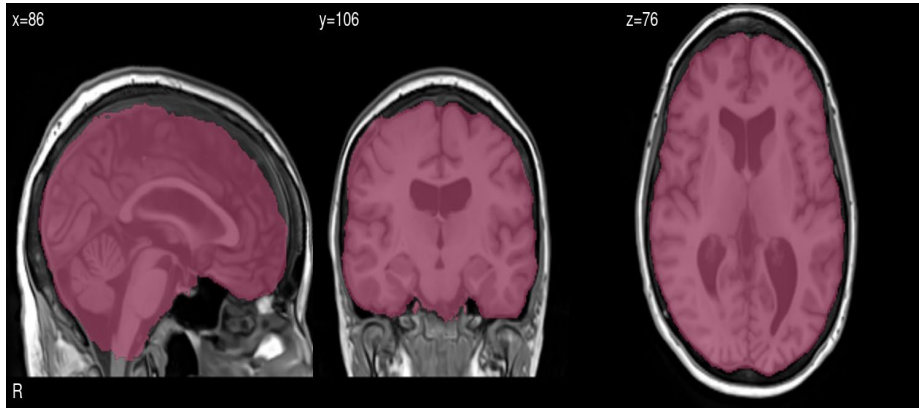
Tips, Tricks, and Mantras

- Know your tool
 - Is it the best tool for the job?
 - Basic+ understanding of how the tool processes your data
 - Expected outputs
 - Limitations
- Neuroanatomy 101
- Multiple looks
- Forest for the trees
- Intervene with caution

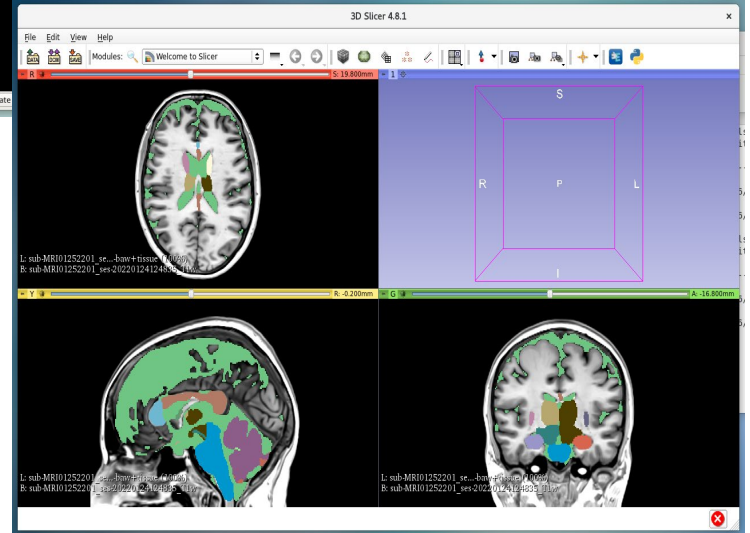
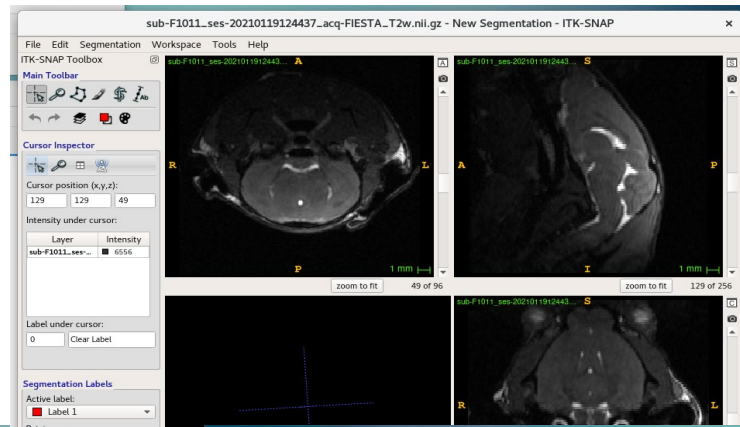
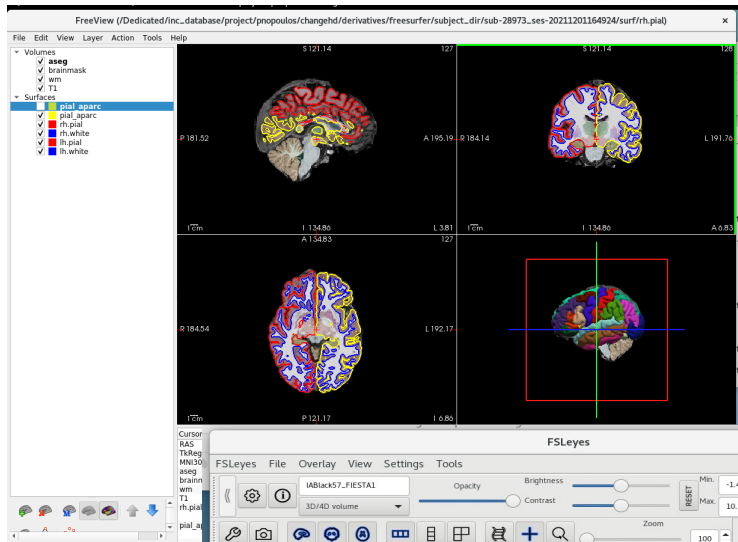


How to QC

- Graphical User Interfaces (GUIs)
 - Slicer, ITKSnap, FSLEyes, AFNI, FreeView, etc
 - Can explore outputs and images more thoroughly
 - Can edit/manipulate outputs and fix some things
 - Different GUIs can interpret parameters differently
 - Slower to load
- PNG maker (<https://research-git.uiowa.edu/inc/code/-/blob/master/export/make3Dpng>)
 - Faster to load
 - Can create images for paper and presentations
 - Cannot navigate the outputs on the fly easily



How to QC GUIs!!!!



How to QC

Example QC csv files to record QC findings:

participant_id,session_id,t1t2registration,labels,notes

(1 is acceptable -1 is failure 0 is questionable)

sub-ECHO2,ses-20191206143006,-1,-1,all T1s are bad due to motion

sub-ECHO1,ses-20190919085919,1,1,-

sub-ECHO4,ses-20211229110107,1,1,-

SubjectID,mri_complete,mri_volumes,mri_volumes_notes,mri_surface_area,

mri_surface_area_notes,mri_dwi,mri_dwi_notes,mri_flair,mri_flair_notes,

mri_t1rho,mri_t1rho_notes,mri_t1rho_ROIs,mri_t1rho_ROIs_notes,mri_asl,

mri_asl_notes,mri_restingstate,mri_restingstate_notes

###Key:1=Valid,2=Not obtained,3=Unanalyzable/Exclude,4=Unknown

D001,No,,,,,,,,,,,,,

D002,Yes,1,,1,,1,minor cerebellum cutoff,4,,4,,#,1,,4,

D003,Yes,3,nosewrap,3,nosewrap,1,moderate cerebellum cutoff,4,,4,,#,1,,4,

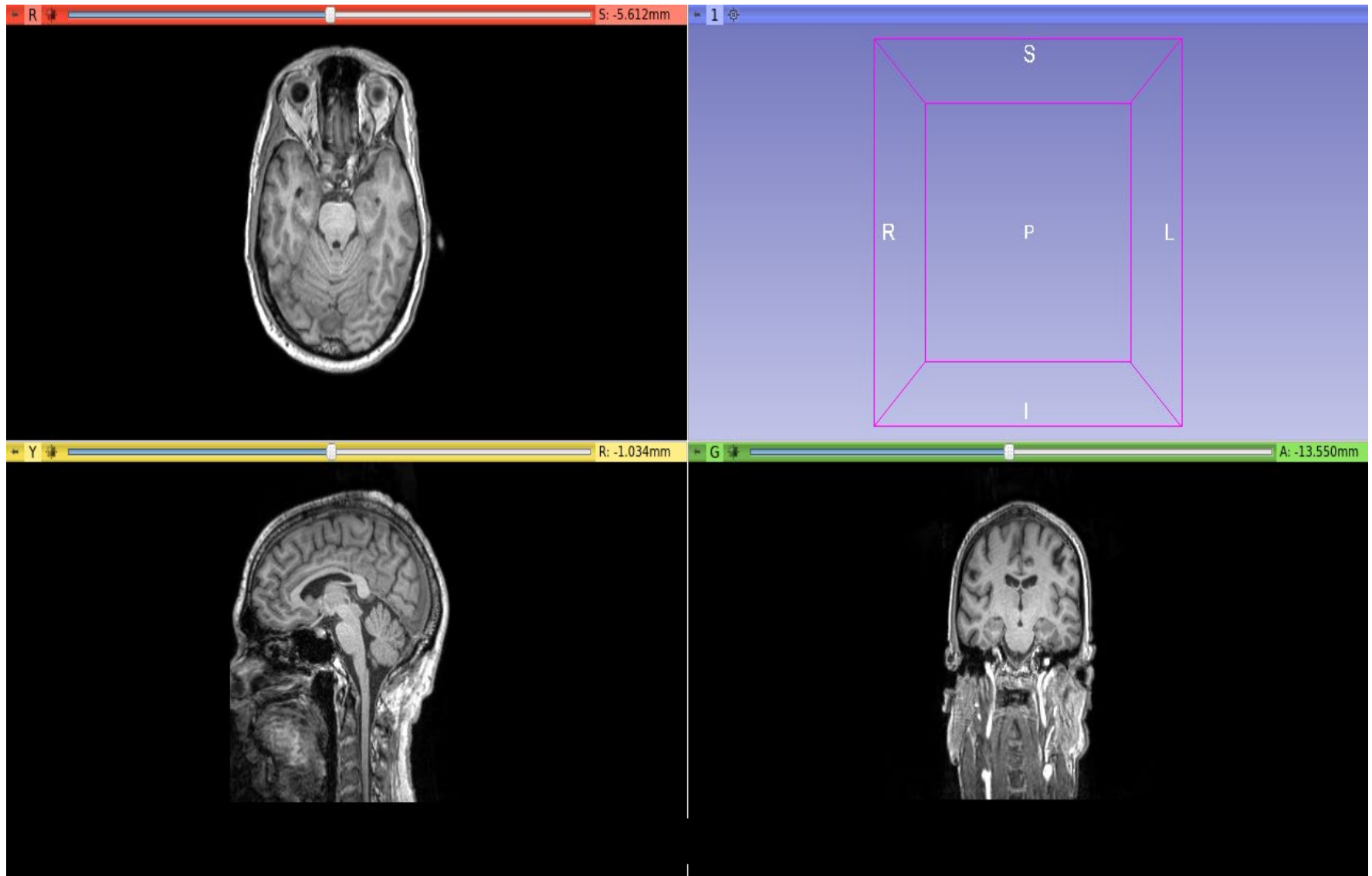
D004,Yes,1,,1,,1,,4,,4,,#,1,,4,

D005,Yes,1,,1,,1,moderate cerebellum cutoff,4,,4,,#,1,,4,

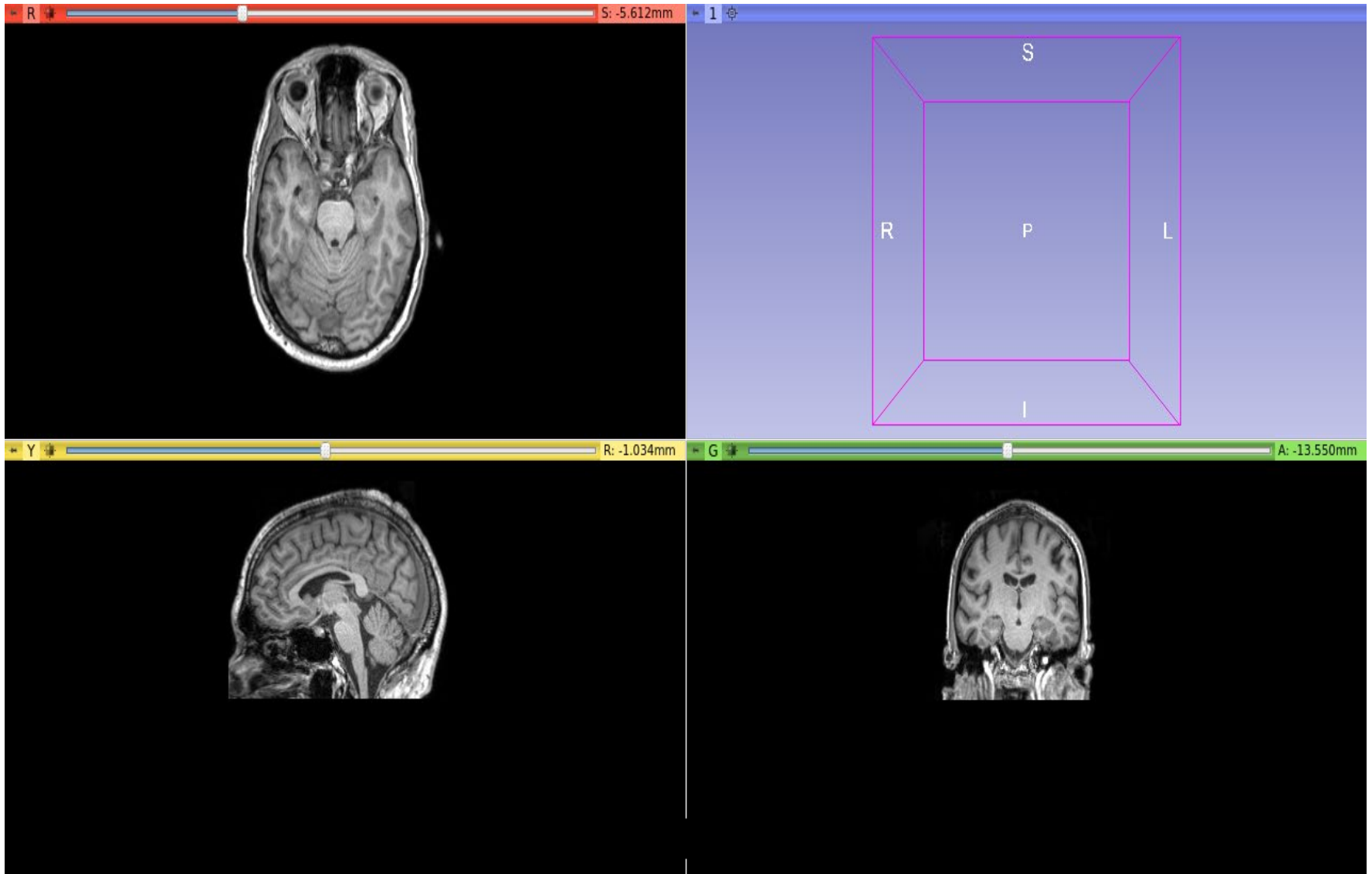
Common Issues

- **Acquisition**
- **Dicom conversion**
- **Registration**
- **Artifacts**
- **Labeling**
- **Sequence specific issues**

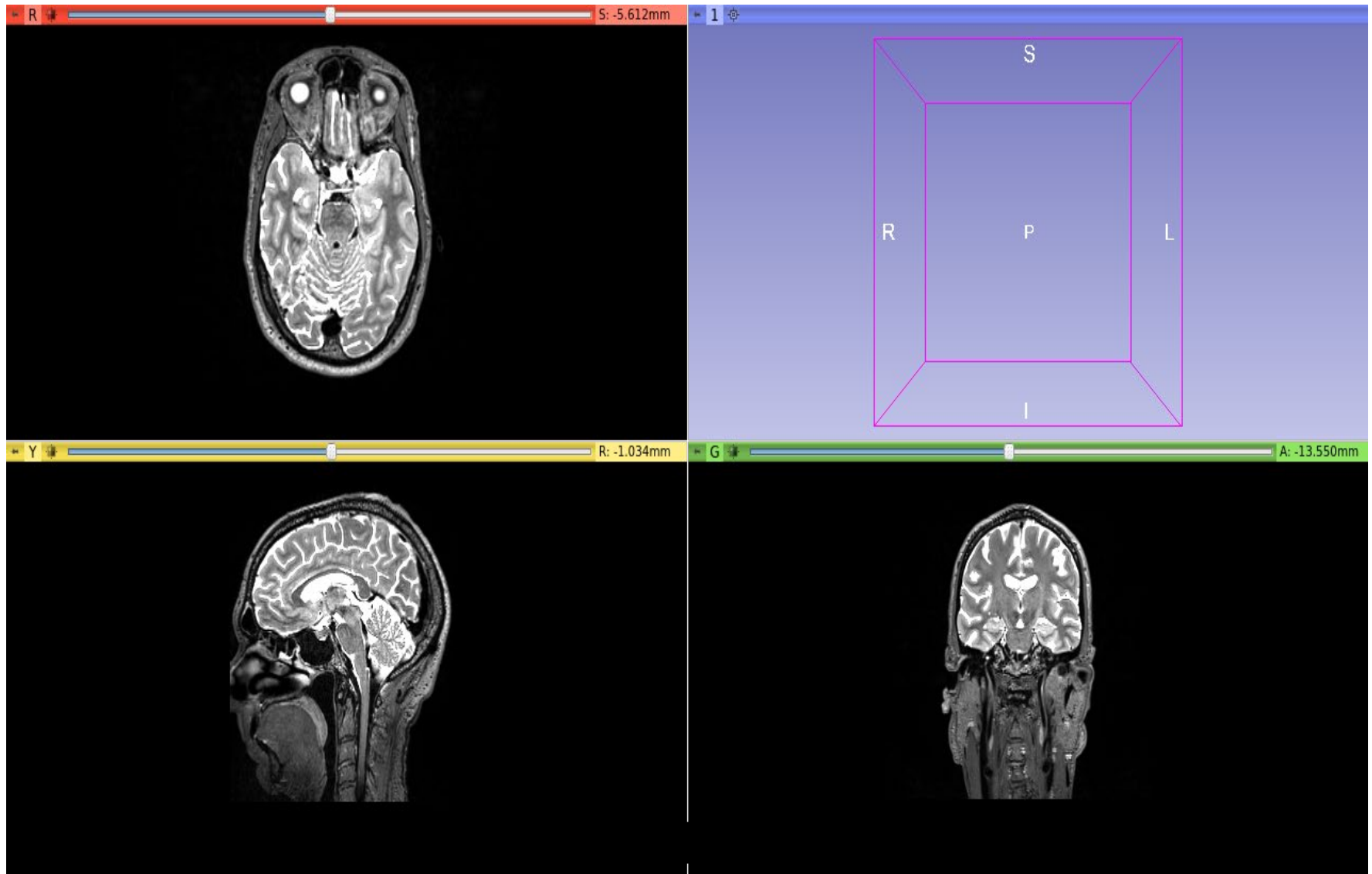
Acquisition: Uncropped T1



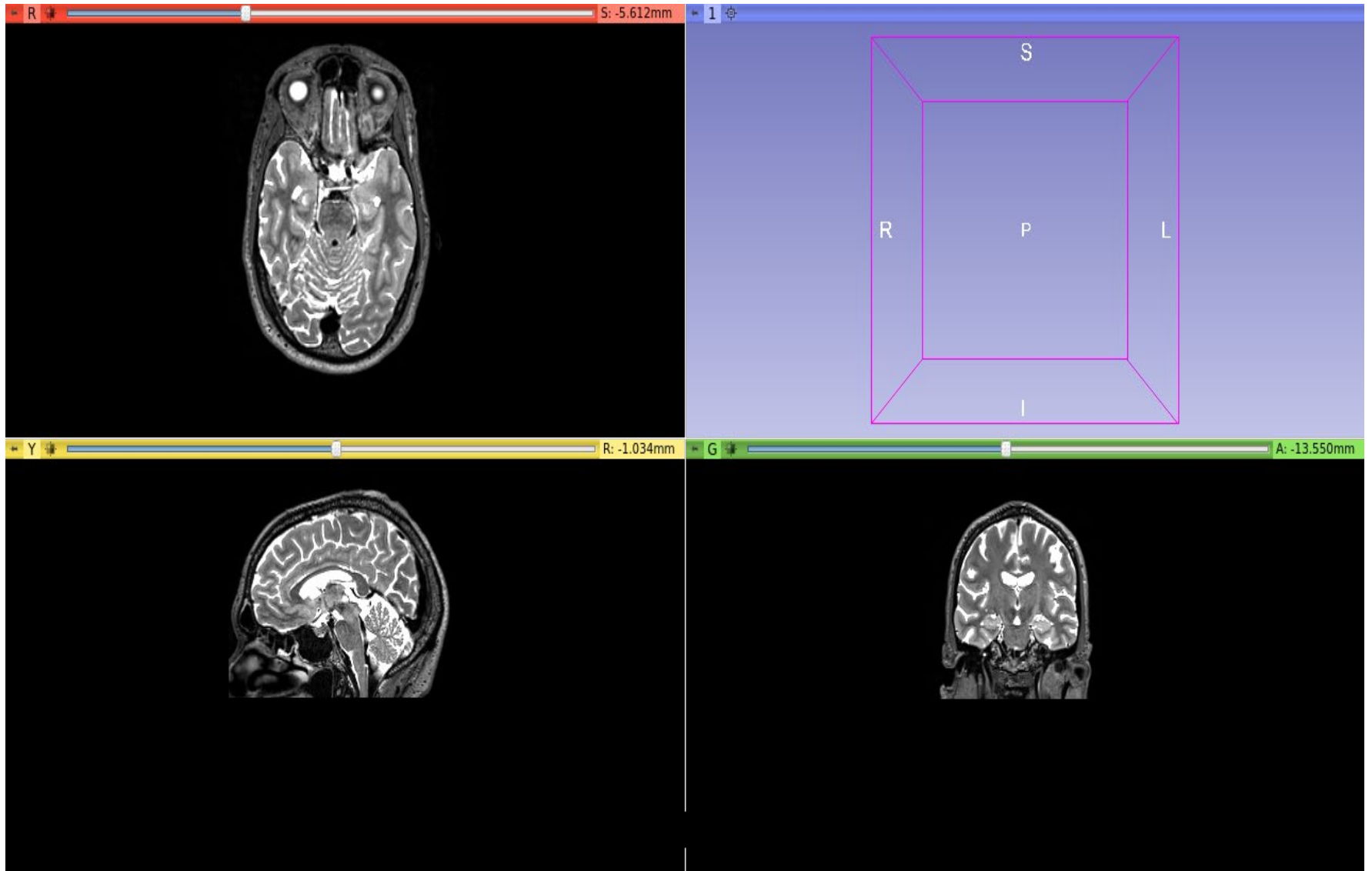
Cropped T1



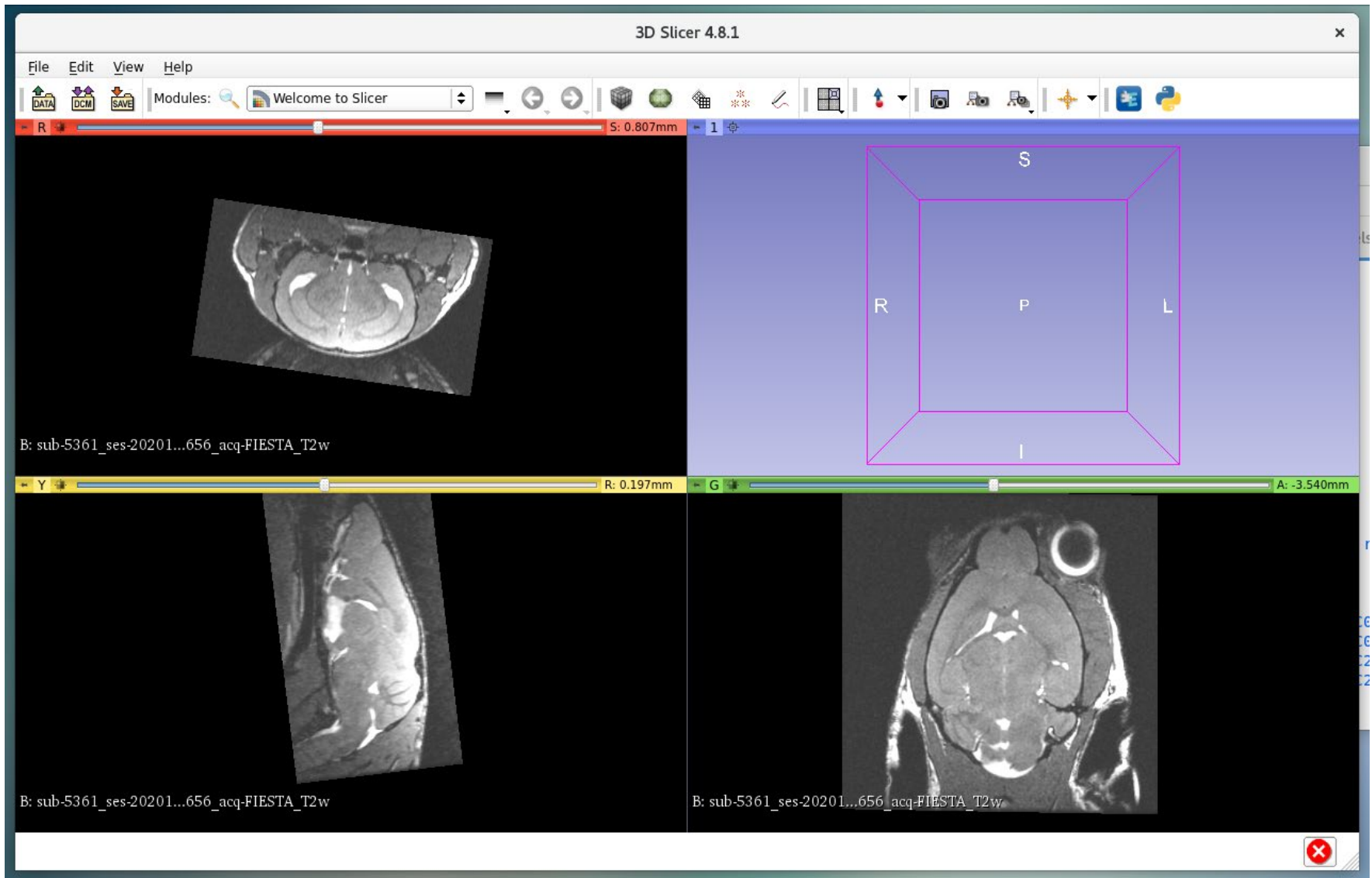
Acquisition: Uncropped T2



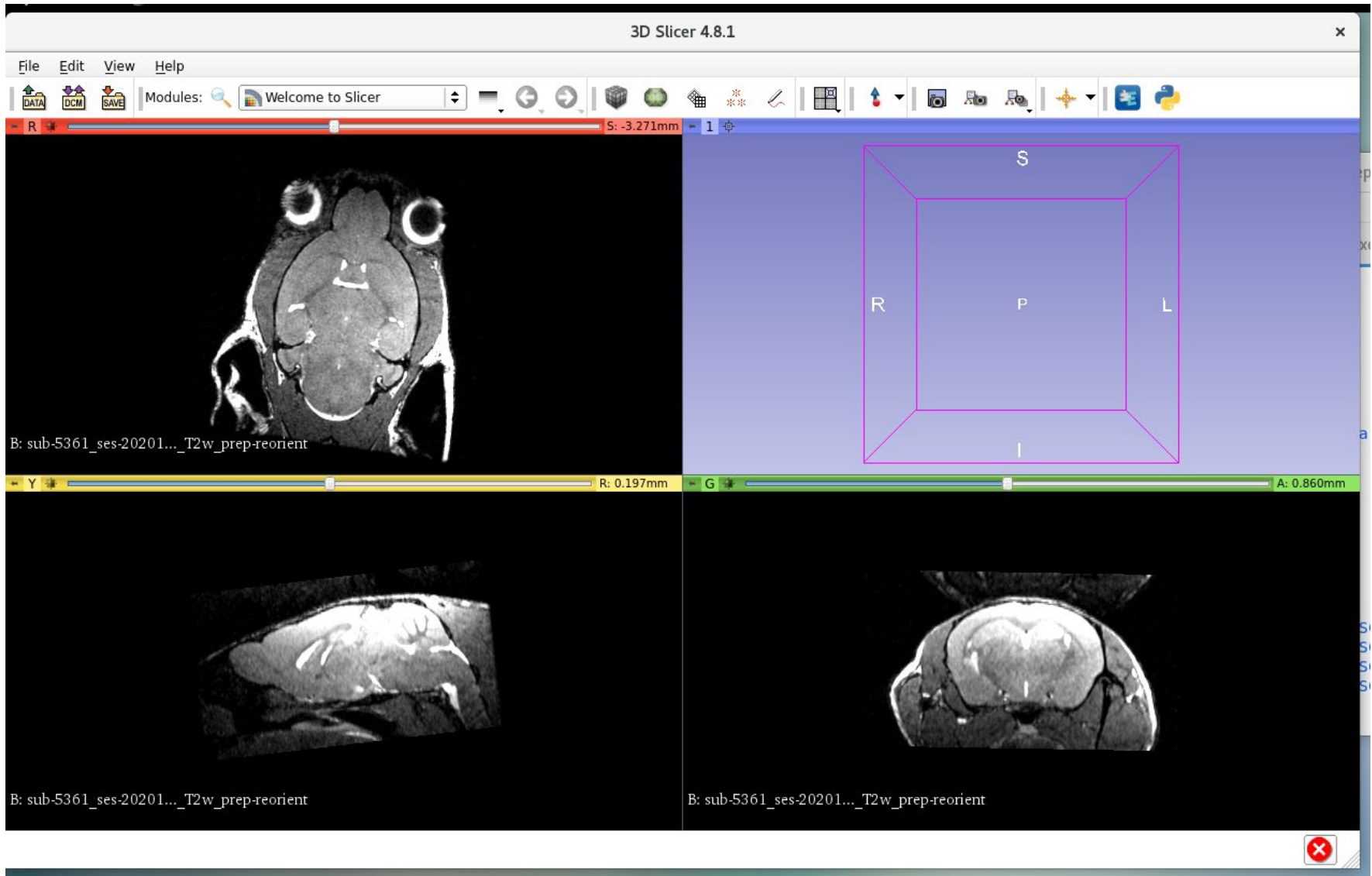
Cropped T2



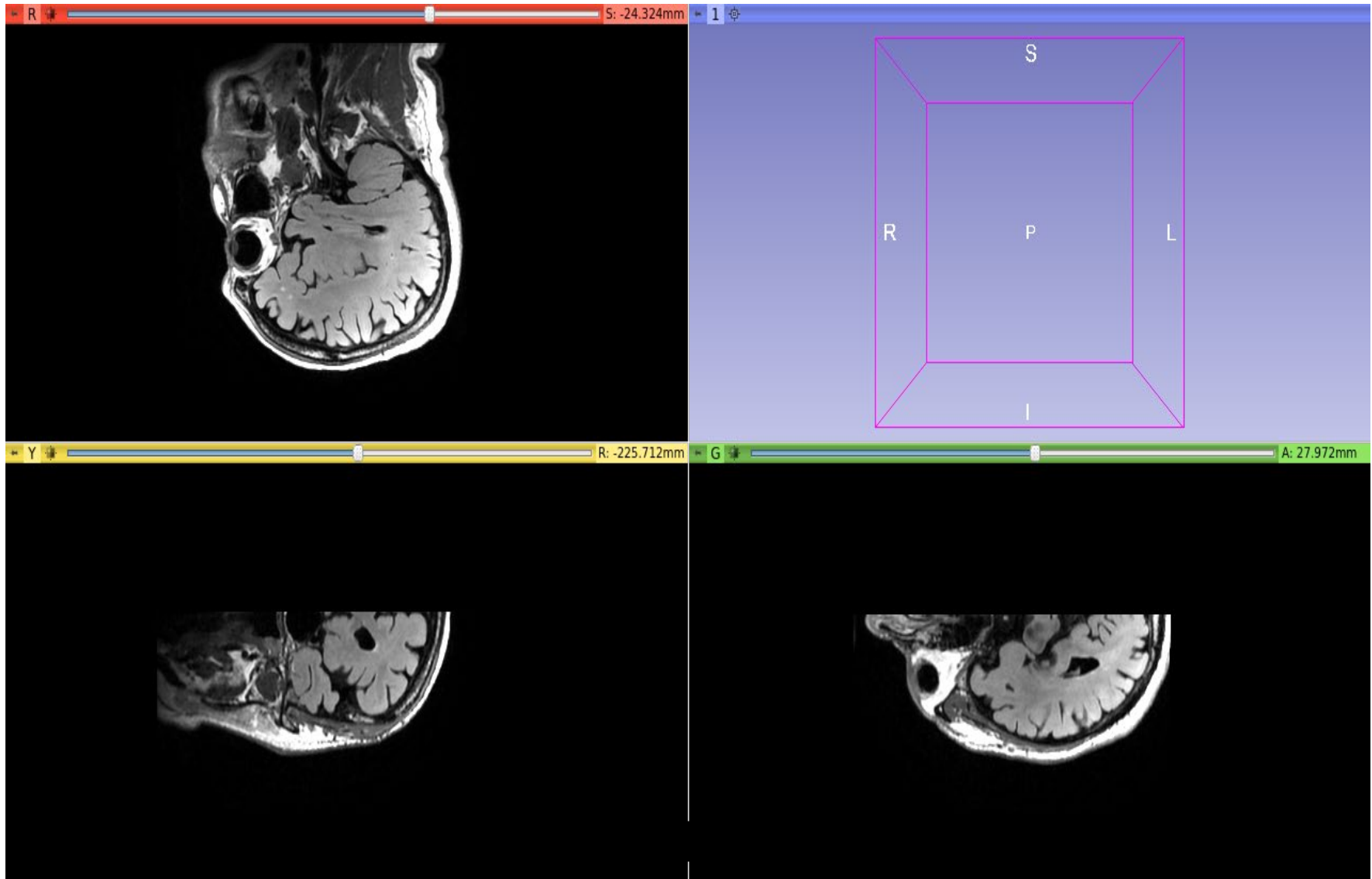
Acquisition: Mouse



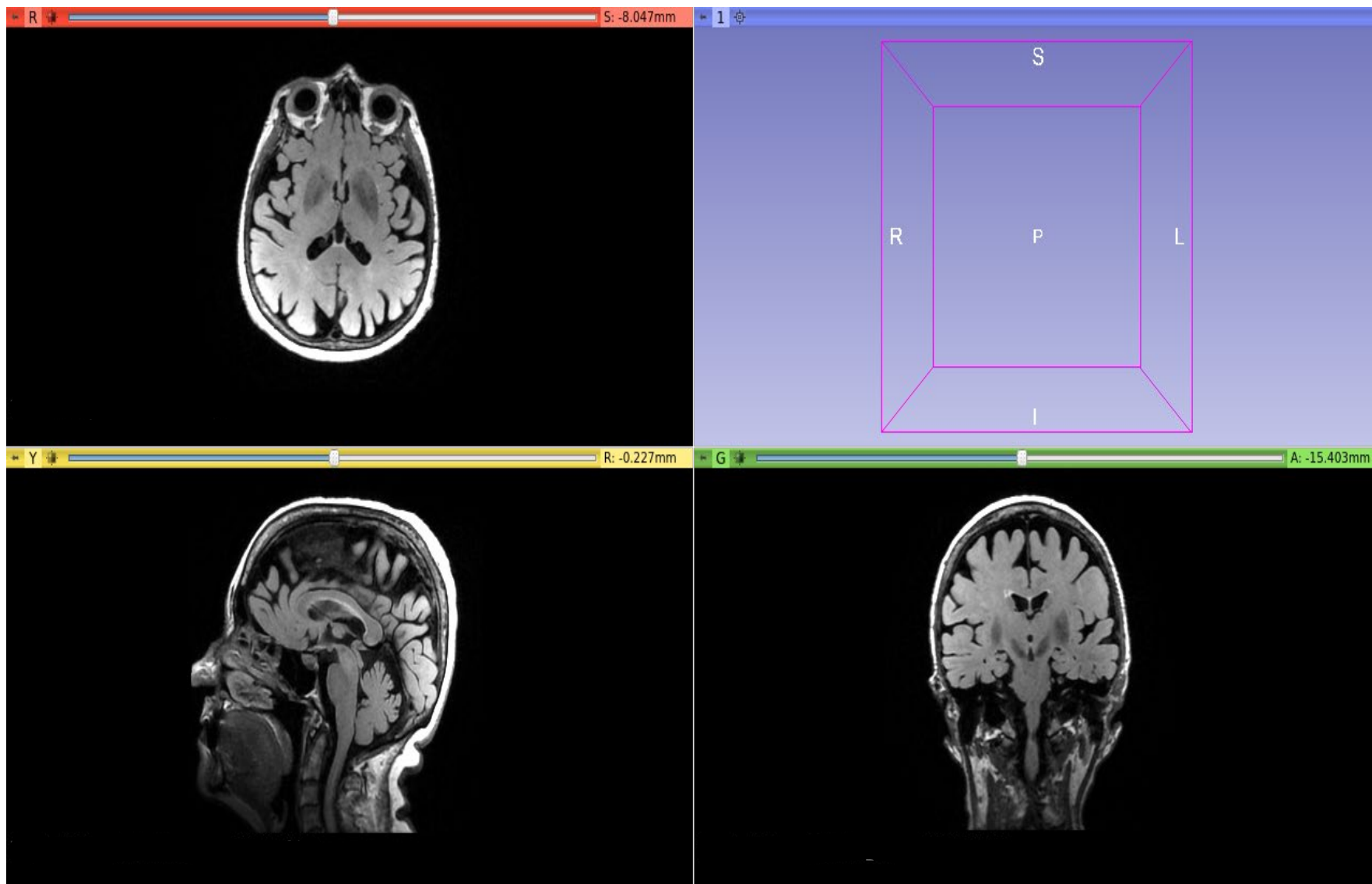
Acquisition: Mouse reoriented



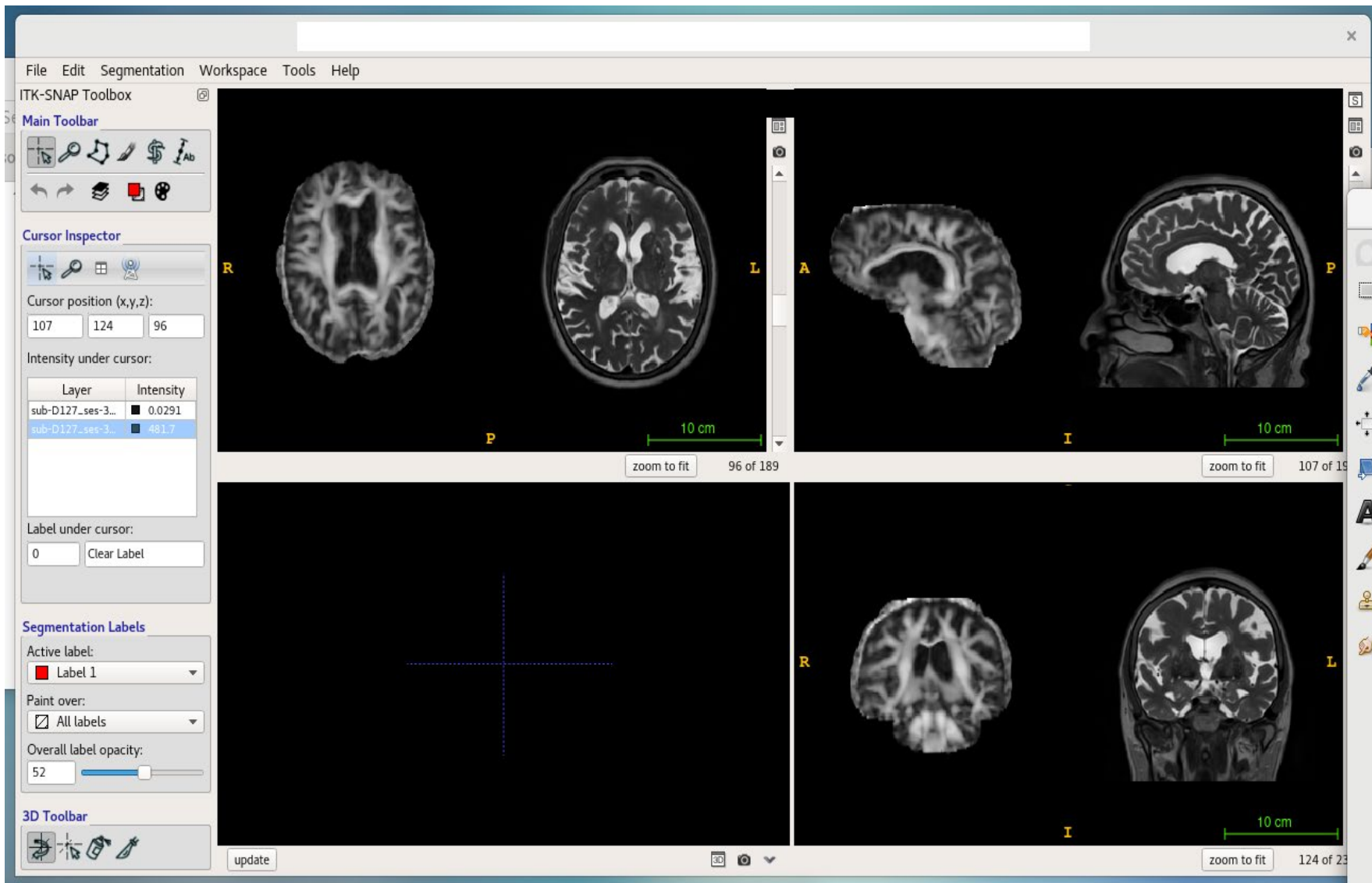
Dicom Conversion: Bad FLAIR dicom conversion



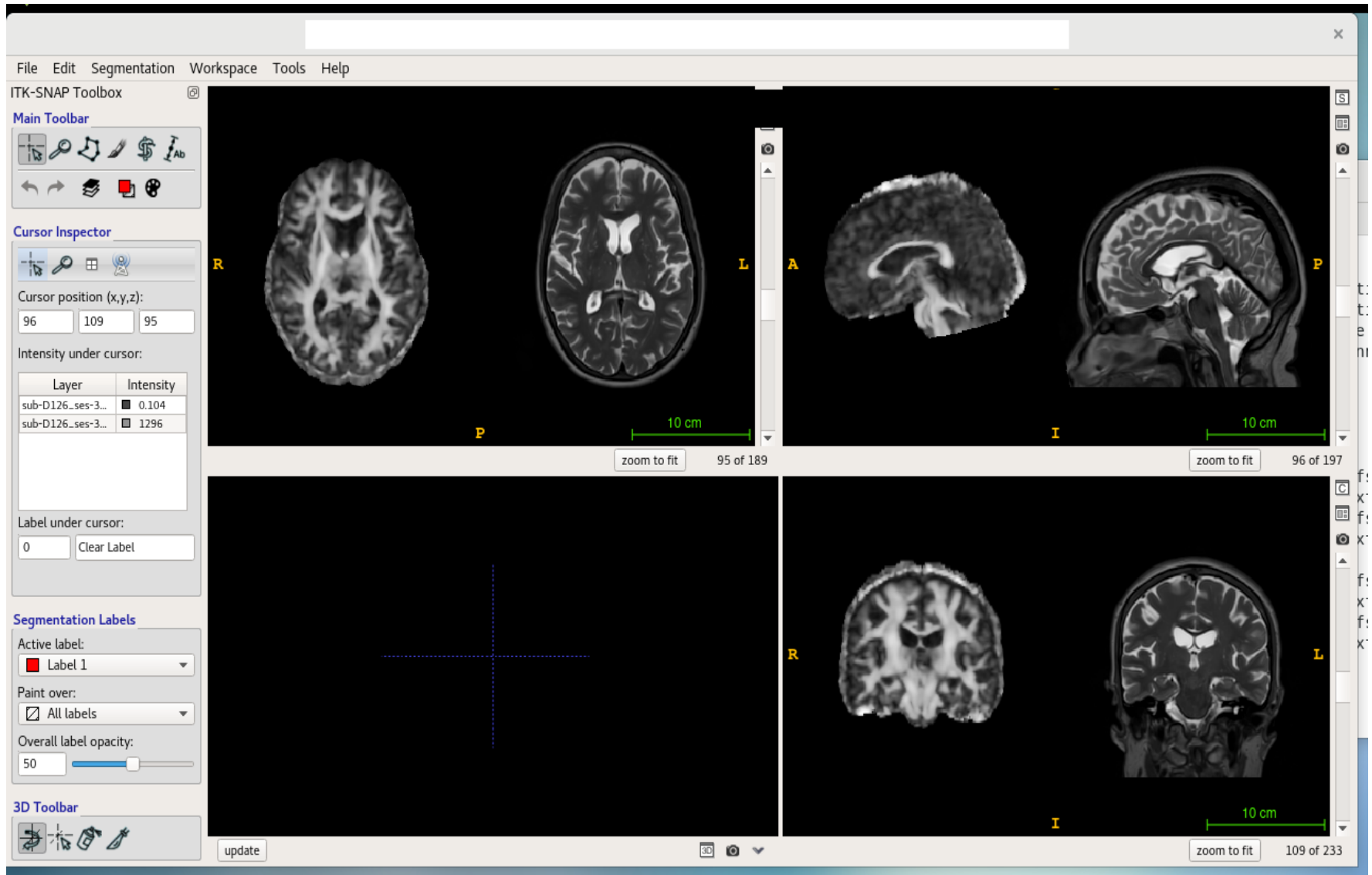
Correct FLAIR dicom conversion



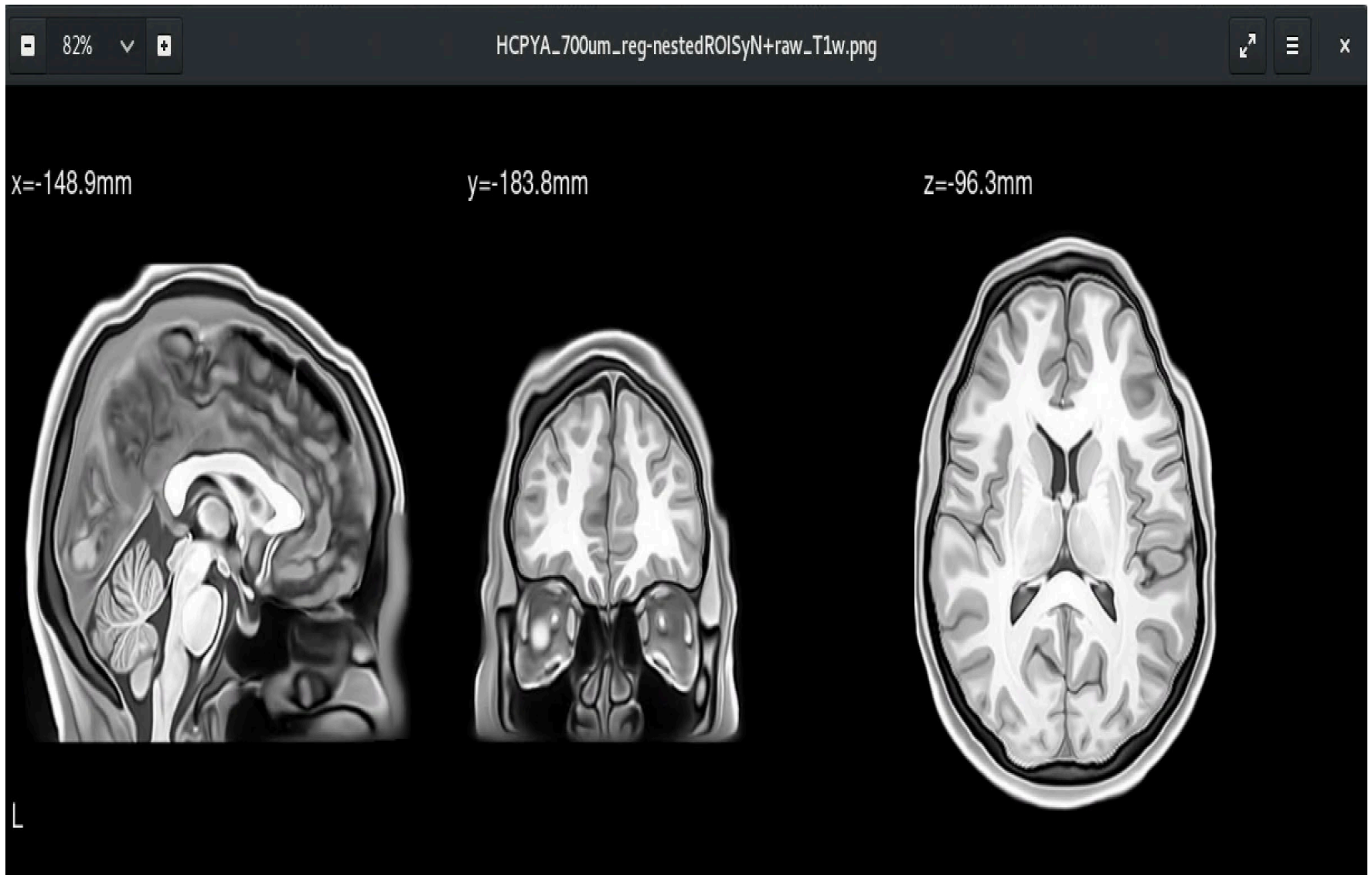
Registration: Bad



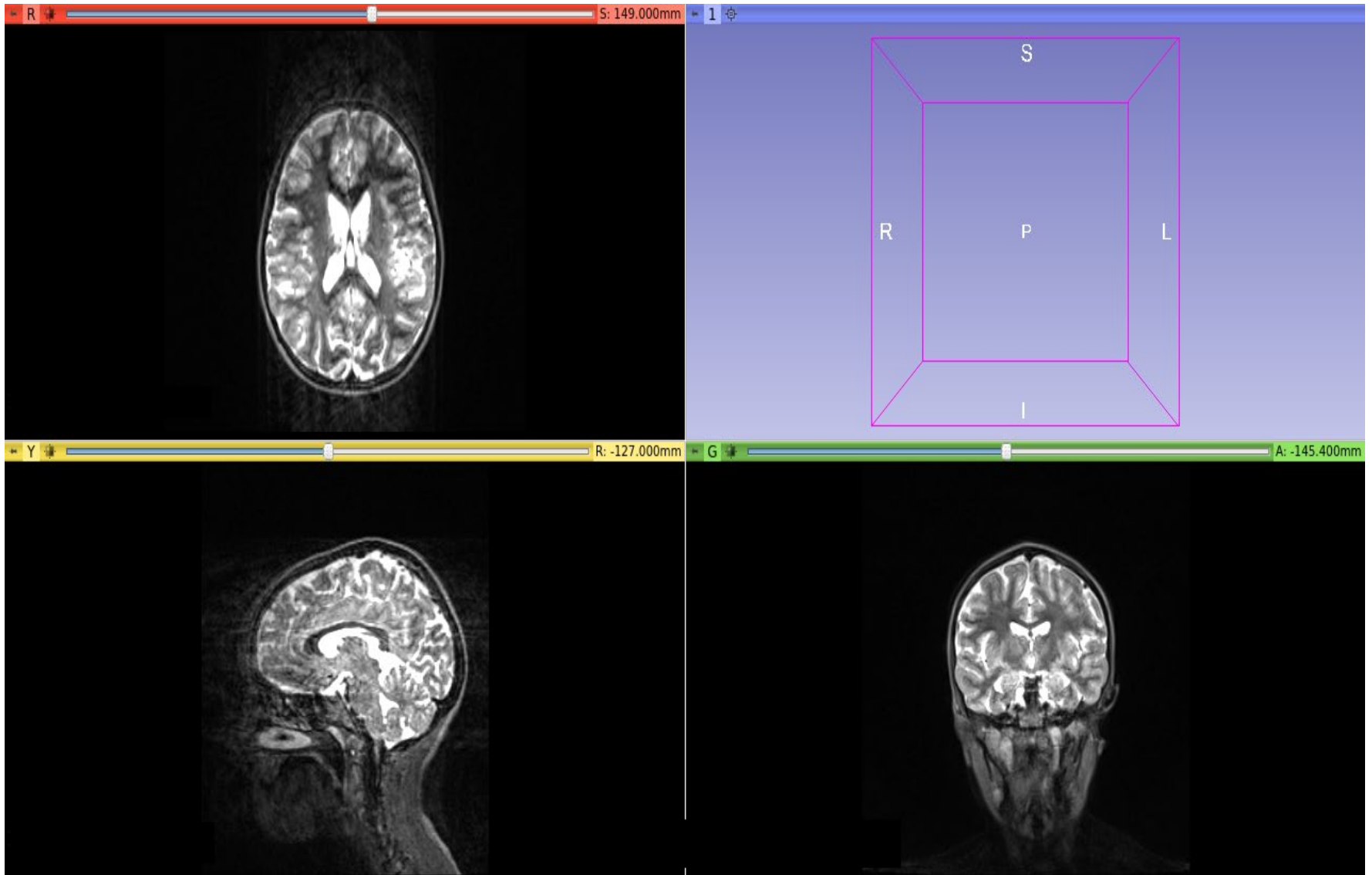
Good registration



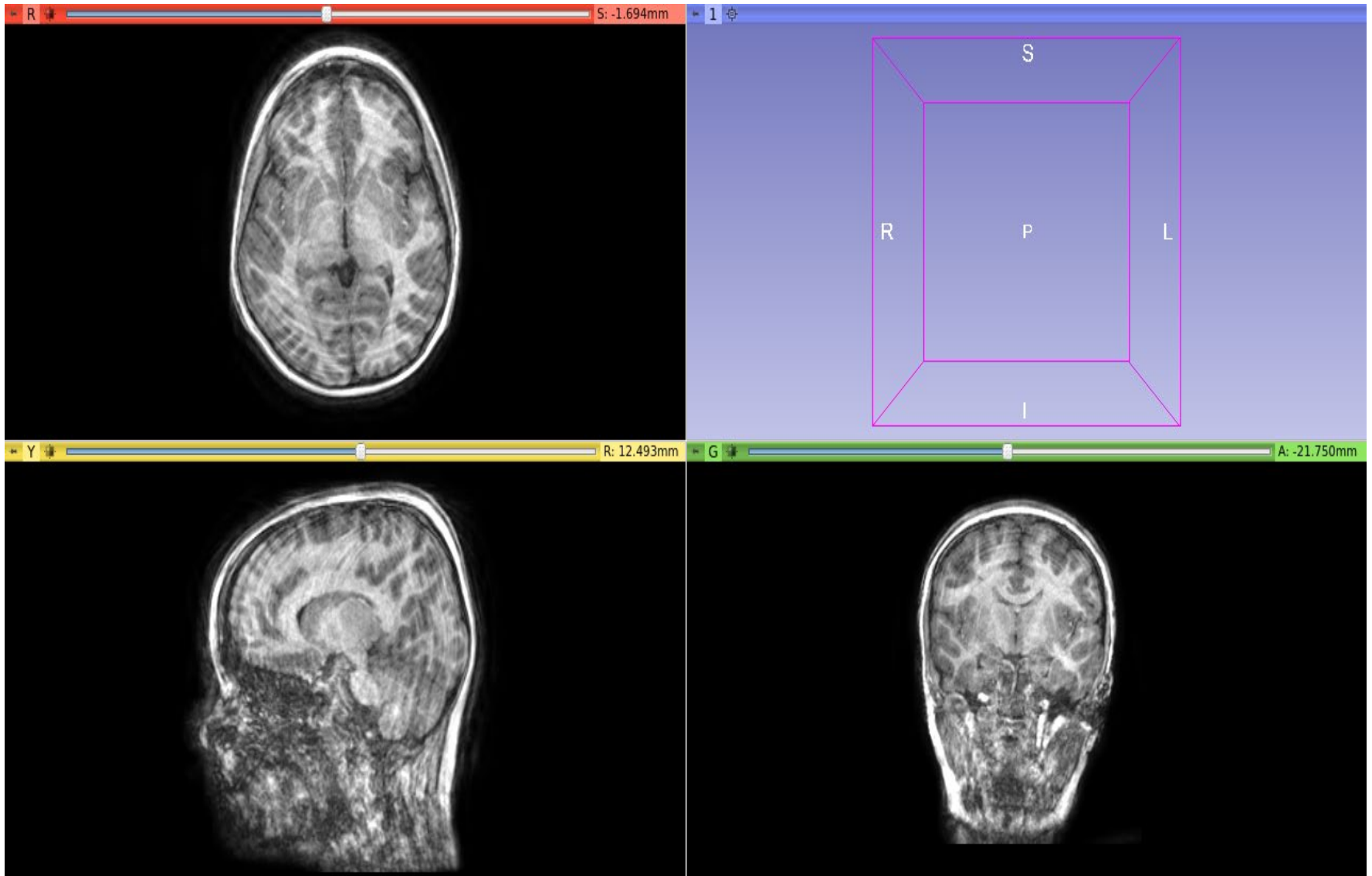
Registration: Bad



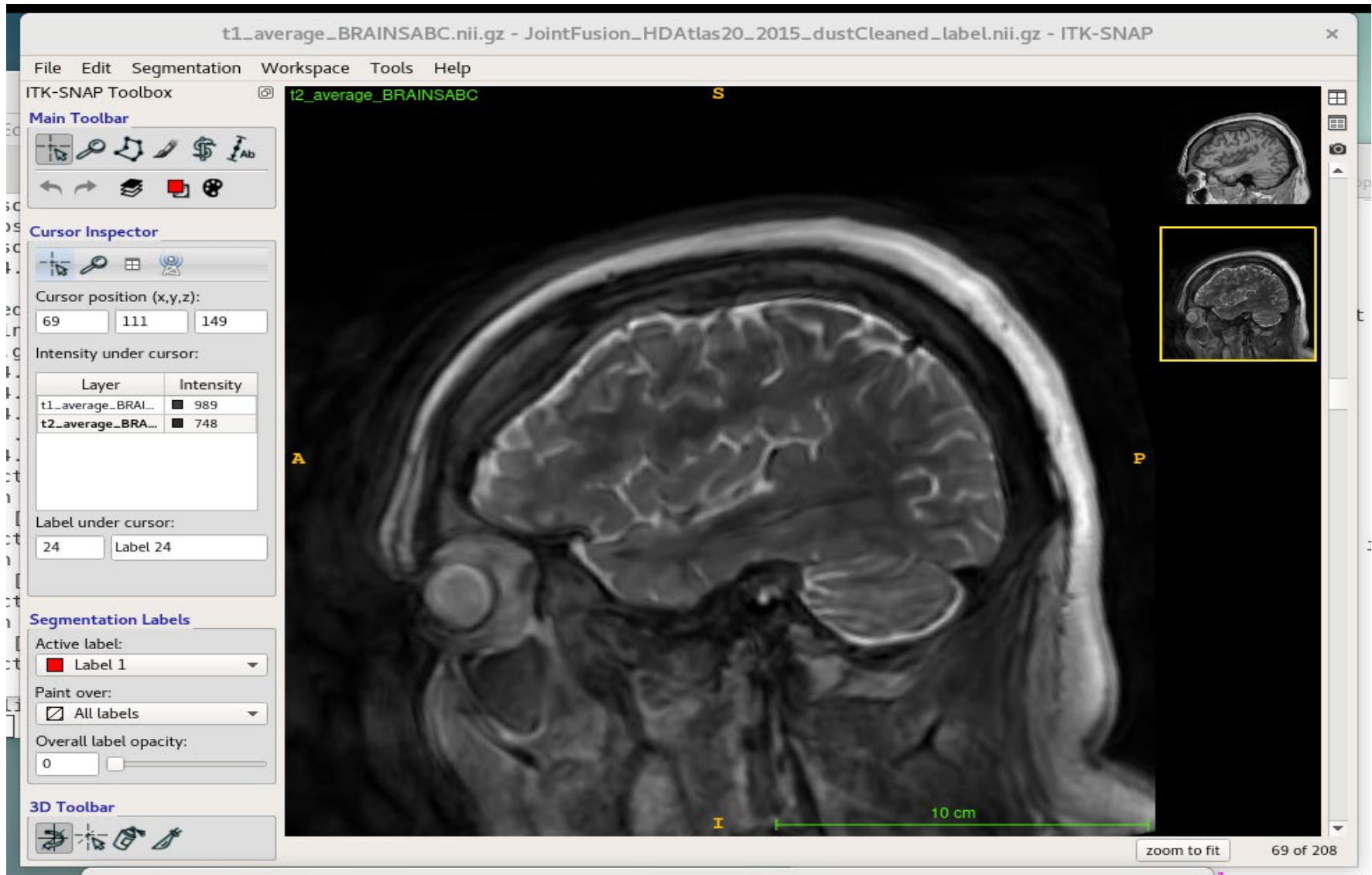
Artifacts: Moderate motion T2



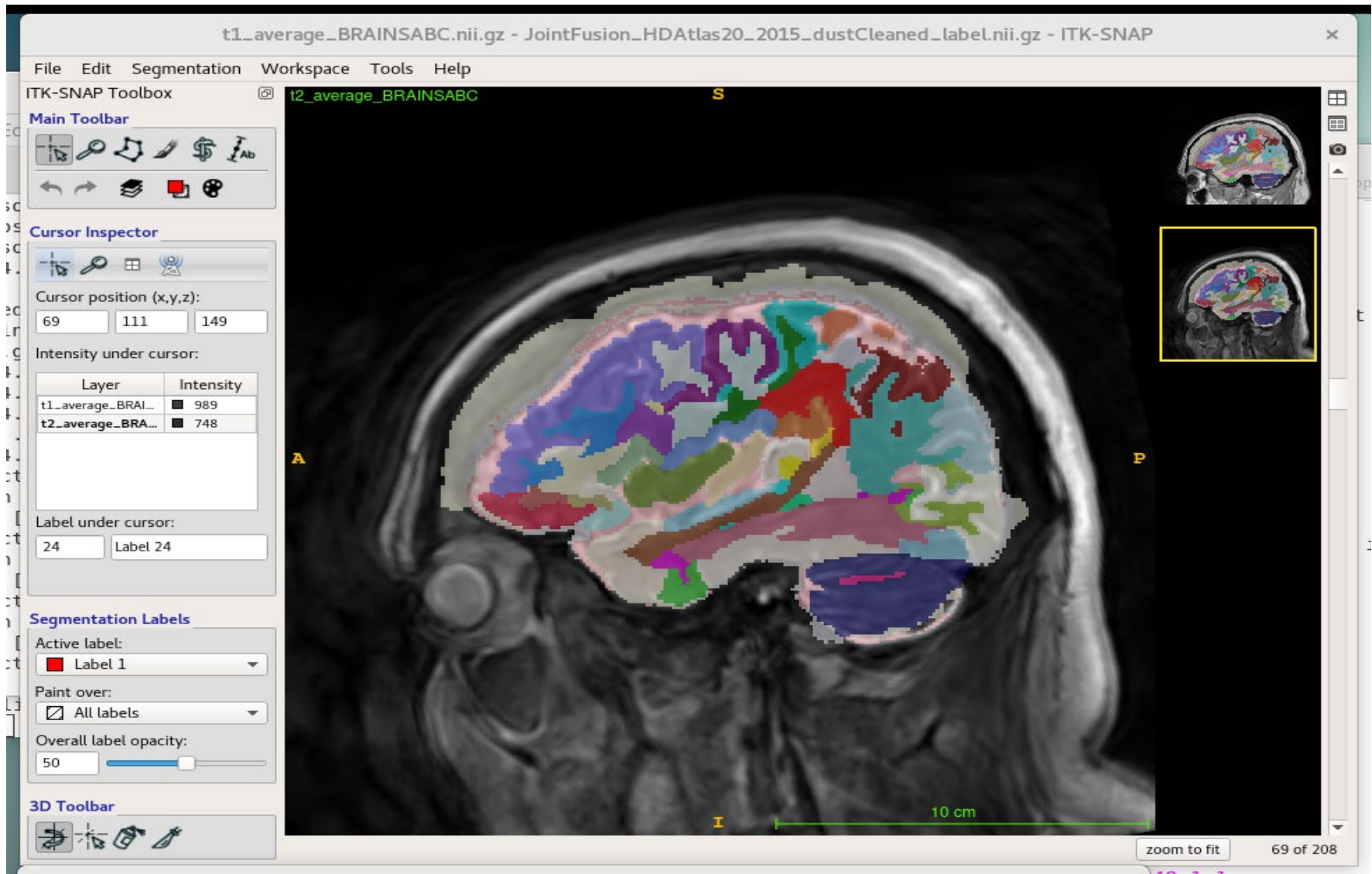
Artifacts: Extreme motion in T1



Artifacts: Moderate T2 motion



Moderate T2 motion labeling in BAW



Moderate-Severe T1/T2 motion FreeSurfer

FreeView (/Dedicated/inc_database/project/evanderplas/scd/derivatives/freesurfer/subject_dir/sub-4406_ses-20220204/surf/rh.pial) x

File Edit View Layer Action Tools Help

Volumes

- aseg
- brainmask
- wm
- T1

Surfaces

- pial_aparc
- pial_aparc
- rh.pial
- rh.white
- lh.pial
- lh.white

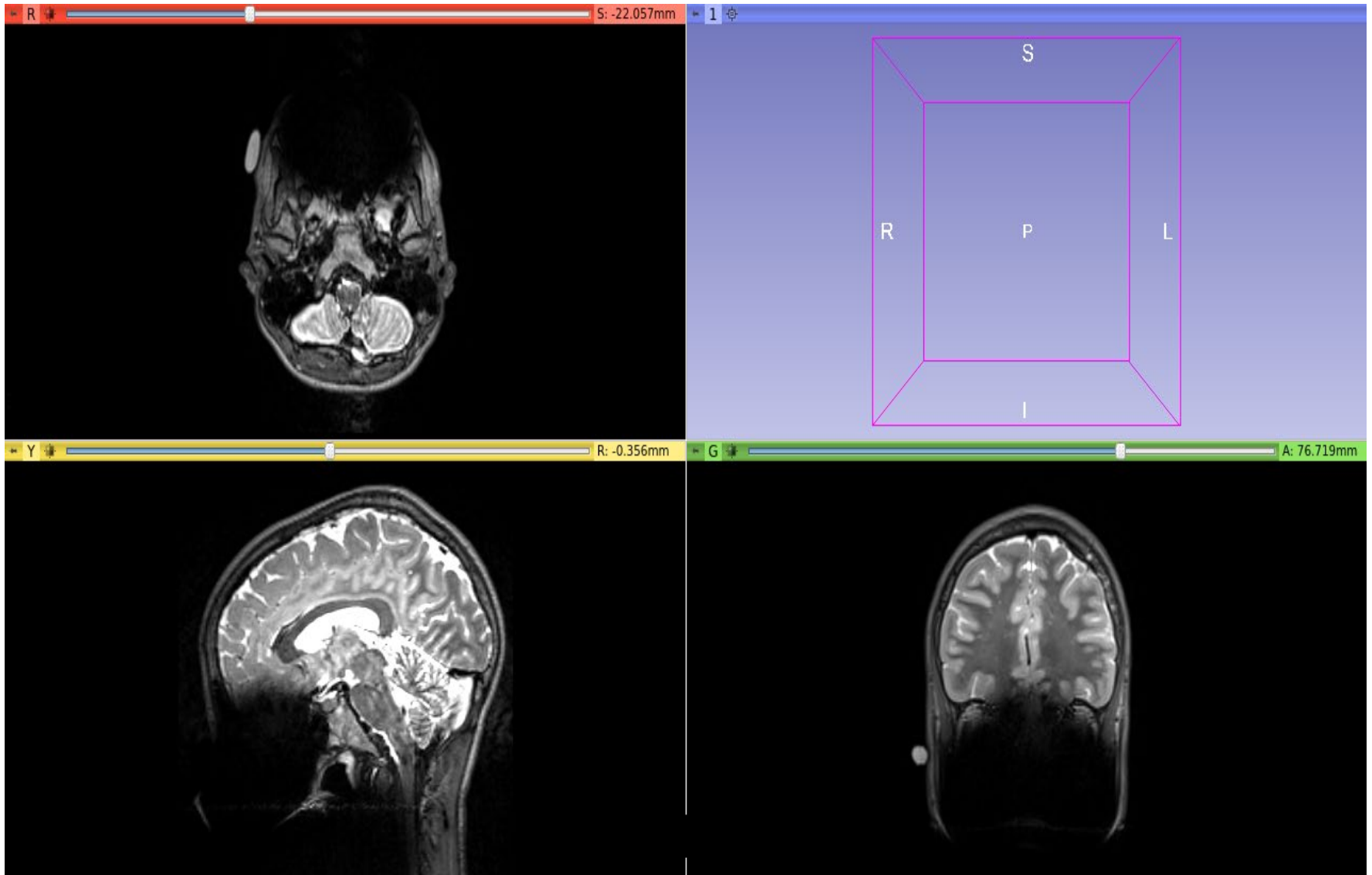
Cursor

RAS	1.21, 5.77, 19.17
TkReg ...(aseg)	-1.04, 4.10, -10.04
MNI305 (aseg)	-5.21, -3.46, 17.15
aseg	4 [129, 138, 132] Left-Lateral-Ventricle
brainmask	29 [129, 138, 132]
wm	250 [129, 138, 132]
T1	29 [129, 138, 132]
pial_aparc	SurfaceRAS [-1.04, 4.10, -10.04]
	Vertex N/A
pial_aparc	SurfaceRAS [-1.04, 4.10, -10.04]
	Vertex N/A

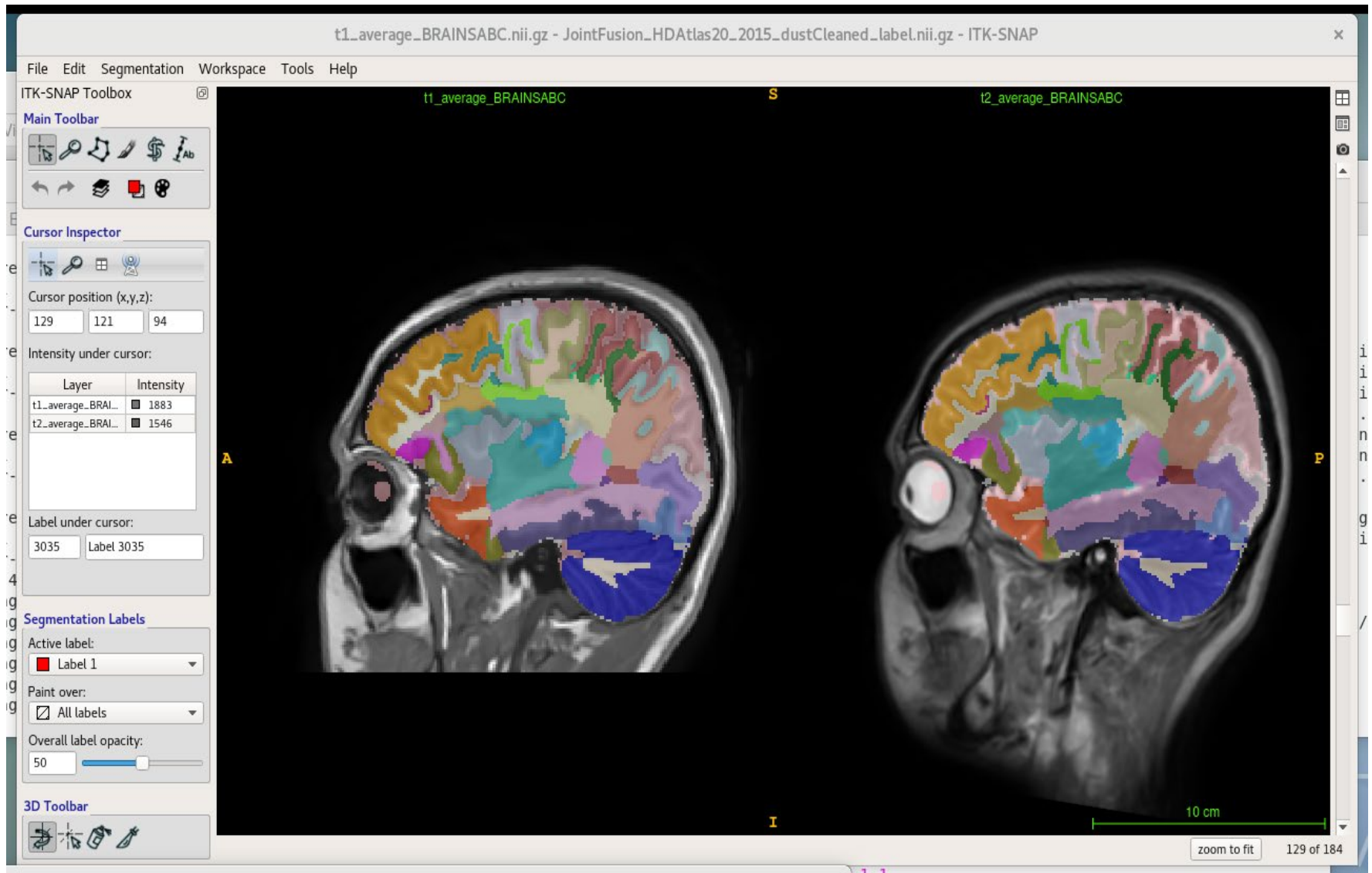
Mouse

RAS	-176.90, 5.77, -78.98
TkReg ...(aseg)	-179.16, 4.10, -108.19
MNI305 (aseg)	-217.26, -29.65, -77.36
aseg	0 [307, 236, 132]
brainmask	0 [307, 236, 132]
wm	0 [307, 236, 132]
T1	0 [307, 236, 132]
pial_aparc	SurfaceRAS [-179.16, 4.10, -108.19]
	Vertex N/A
pial_aparc	SurfaceRAS [-179.16, 4.10, -108.19]
	Vertex N/A

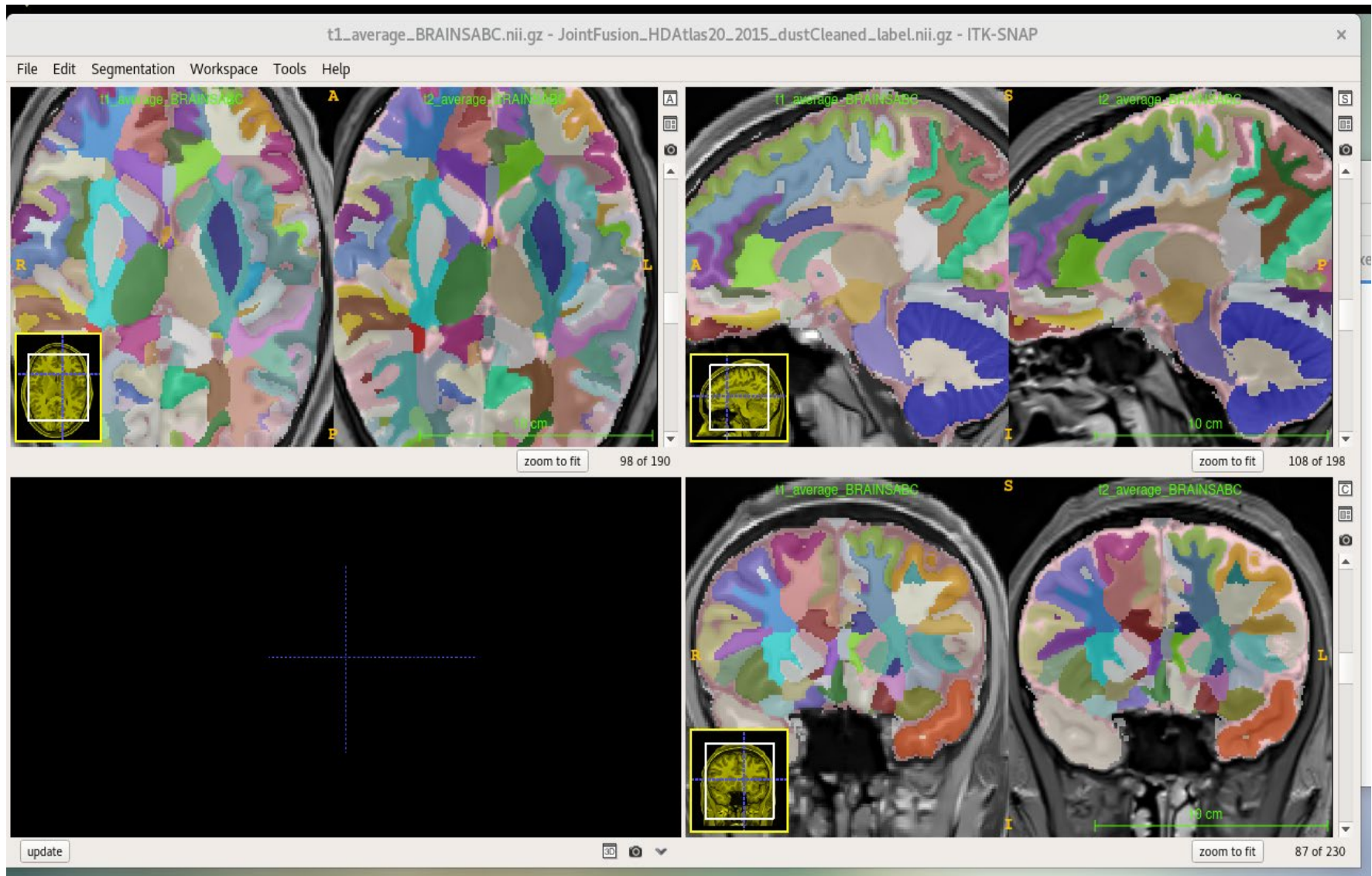
Artifacts: Braces



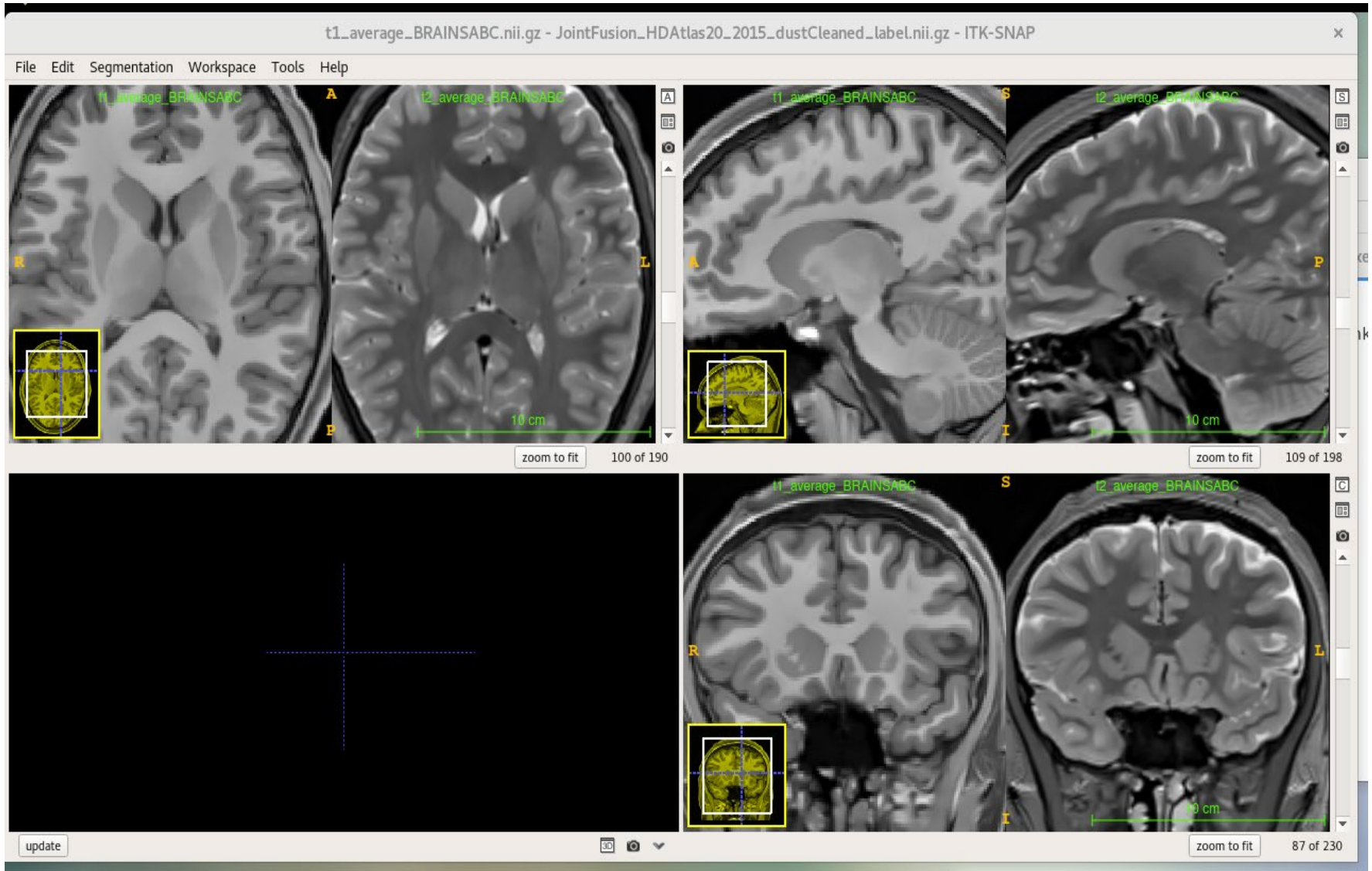
Labeling: CSF mislabeled in eyeball



Labeling: Baw mislabeled CSF in caudate



Reference unlabeled T1 T2




Labeling: Unlabeled FLAIR

sub-5076_ses-3hwjhb1pai_site-00201_FLAIR.nii.gz - sub-5076_ses-3hwjhb1pai_label-hyperWM.nii.gz - ITK-SNAP

File Edit Segmentation Workspace Tools Help

ITK-SNAP Toolbox

Main Toolbar



Cursor Inspector

Cursor position (x,y,z):
62 111 110

Intensity under cursor:

Layer	Intensity
sub-5076_ses+3...	1810
sub-5076_ses-3h...	649.3

Label under cursor:
1 Label 1

Segmentation Labels

Active label:
Label 1

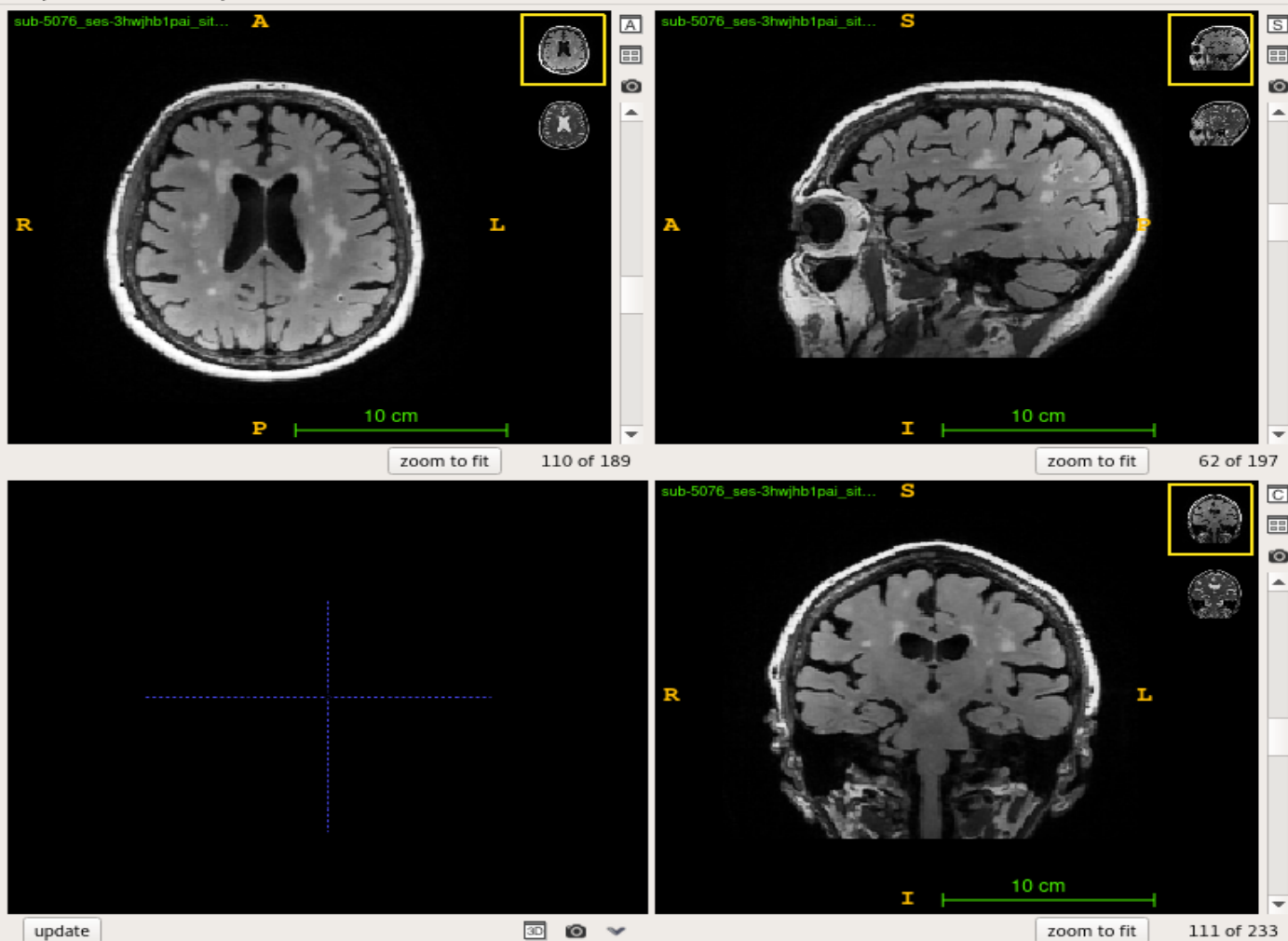
Paint over:
All labels

Overall label opacity:
0

3D Toolbar



update




FLAIR with samseg hyperintense labeling

sub-5076_ses-3hwjhb1pai_site-00201_FLAIR.nii.gz - sub-5076_ses-3hwjhb1pai_label-hyperWM.nii.gz - ITK-SNAP

File Edit Segmentation Workspace Tools Help

ITK-SNAP Toolbox

Main Toolbar



Cursor Inspector

Cursor position (x,y,z):
62 111 110

Intensity under cursor:

Layer	Intensity
sub-5076_ses+3...	1810
sub-5076_ses-3h...	649.3

Label under cursor:
1 Label 1


Segmentation Labels

Active label:
Label 1

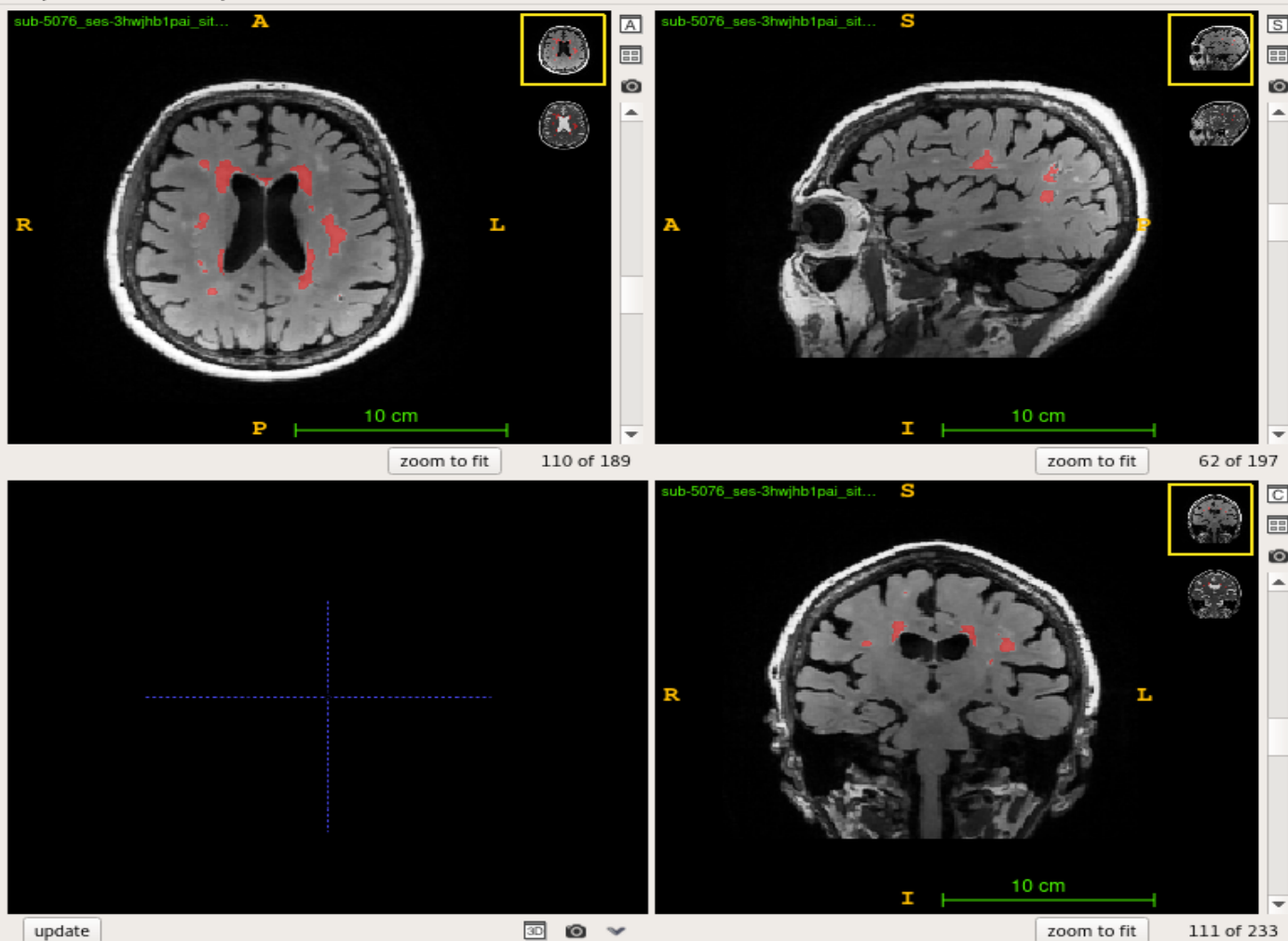
Paint over:
All labels

Overall label opacity:
49

3D Toolbar



update




FLAIR with ventricular lesions/capping

sub-5014_ses-32abad5dbl_site-00201_FLAIR.nii.gz - sub-5014_ses-32abad5dbl_label-hyperWM.nii.gz - ITK-SNAP

File Edit Segmentation Workspace Tools Help

ITK-SNAP Toolbox

Main Toolbar



Cursor Inspector

Cursor position (x,y,z):
76 92 105

Intensity under cursor:

Layer	Intensity
sub-5014_ses-3...	619
sub-5014_ses-32...	86.48

Label under cursor:
1 Label 1

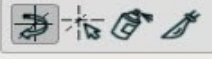
Segmentation Labels

Active label:
Label 1

Paint over:
 All labels

Overall label opacity:
0

3D Toolbar

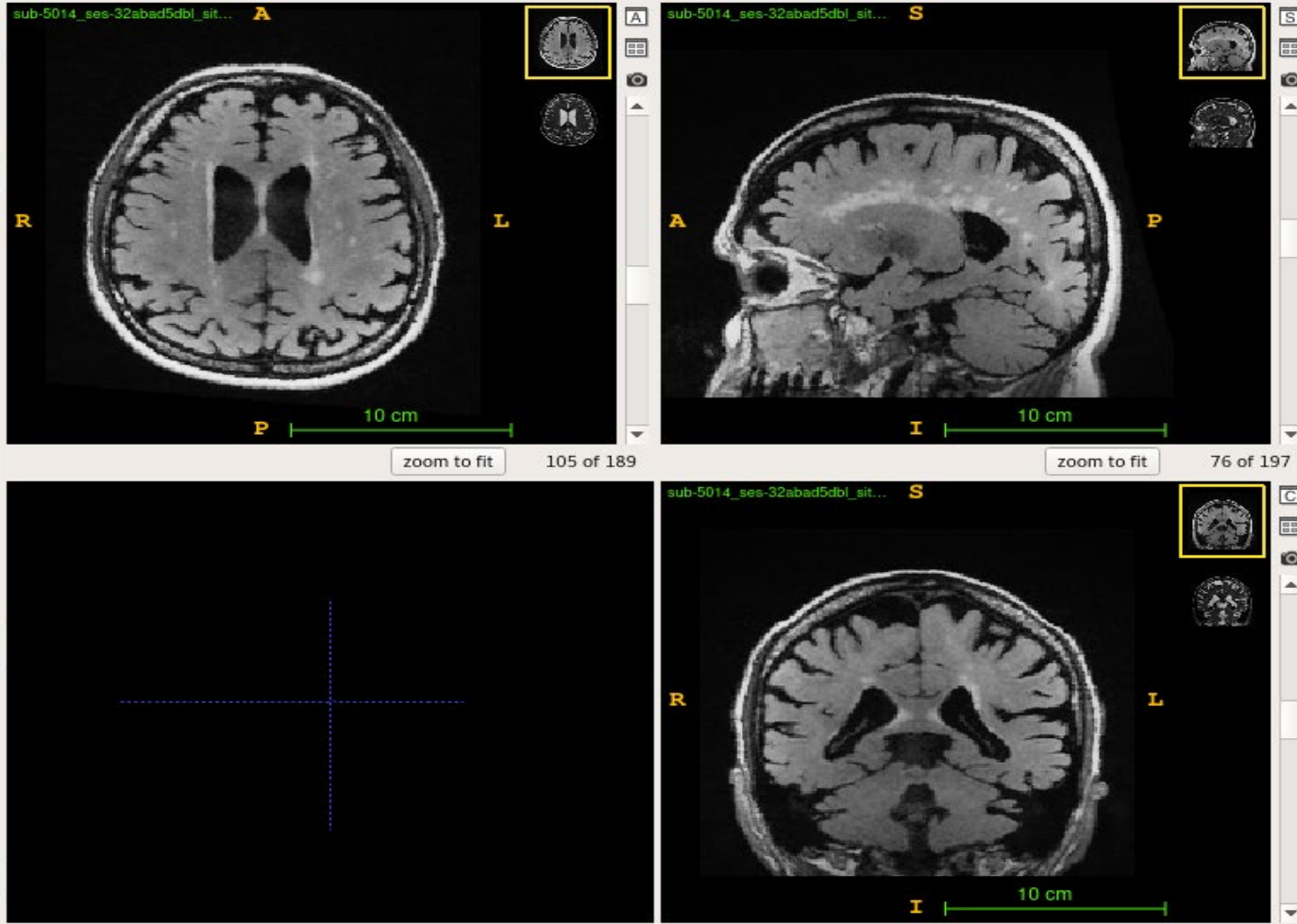


zoom to fit 105 of 189

zoom to fit 76 of 197

update

zoom to fit 92 of 233



FLAIR with samseg hyperintense label

sub-5014_ses-32abad5dbl_site-00201_FLAIR.nii.gz - sub-5014_ses-32abad5dbl_label-hyperWM.nii.gz - ITK-SNAP

File Edit Segmentation Workspace Tools Help

ITK-SNAP Toolbox

Main Toolbar

Cursor Inspector

Cursor position (x,y,z):
76 92 105

Intensity under cursor:

Layer	Intensity
sub-5014_ses-32...	619
sub-5014_ses-32...	86.48

Label under cursor:
1 Label 1

Segmentation Labels

Active label:
Label 1

Paint over:
All labels

Overall label opacity:
50

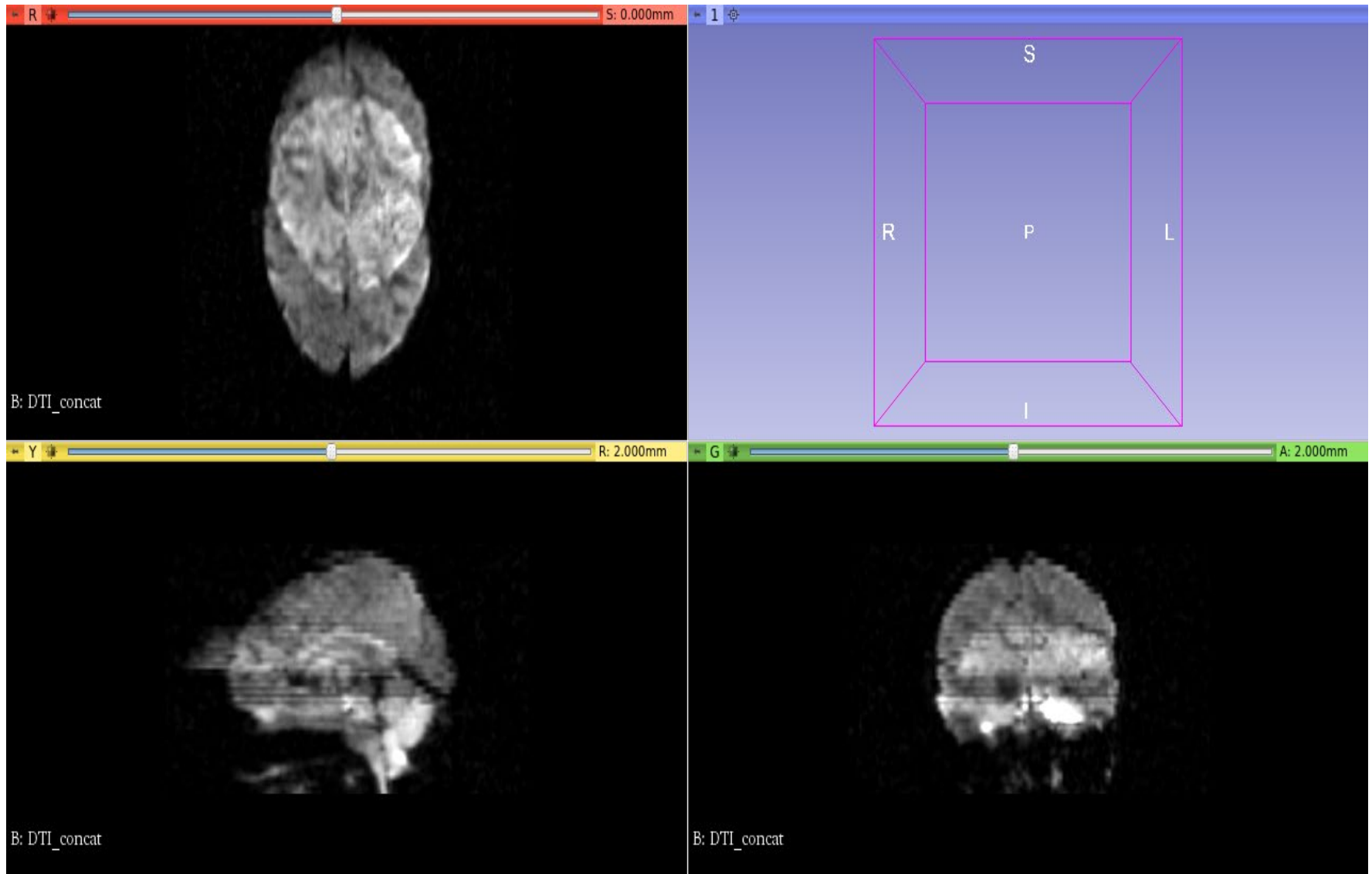
3D Toolbar

105 of 189

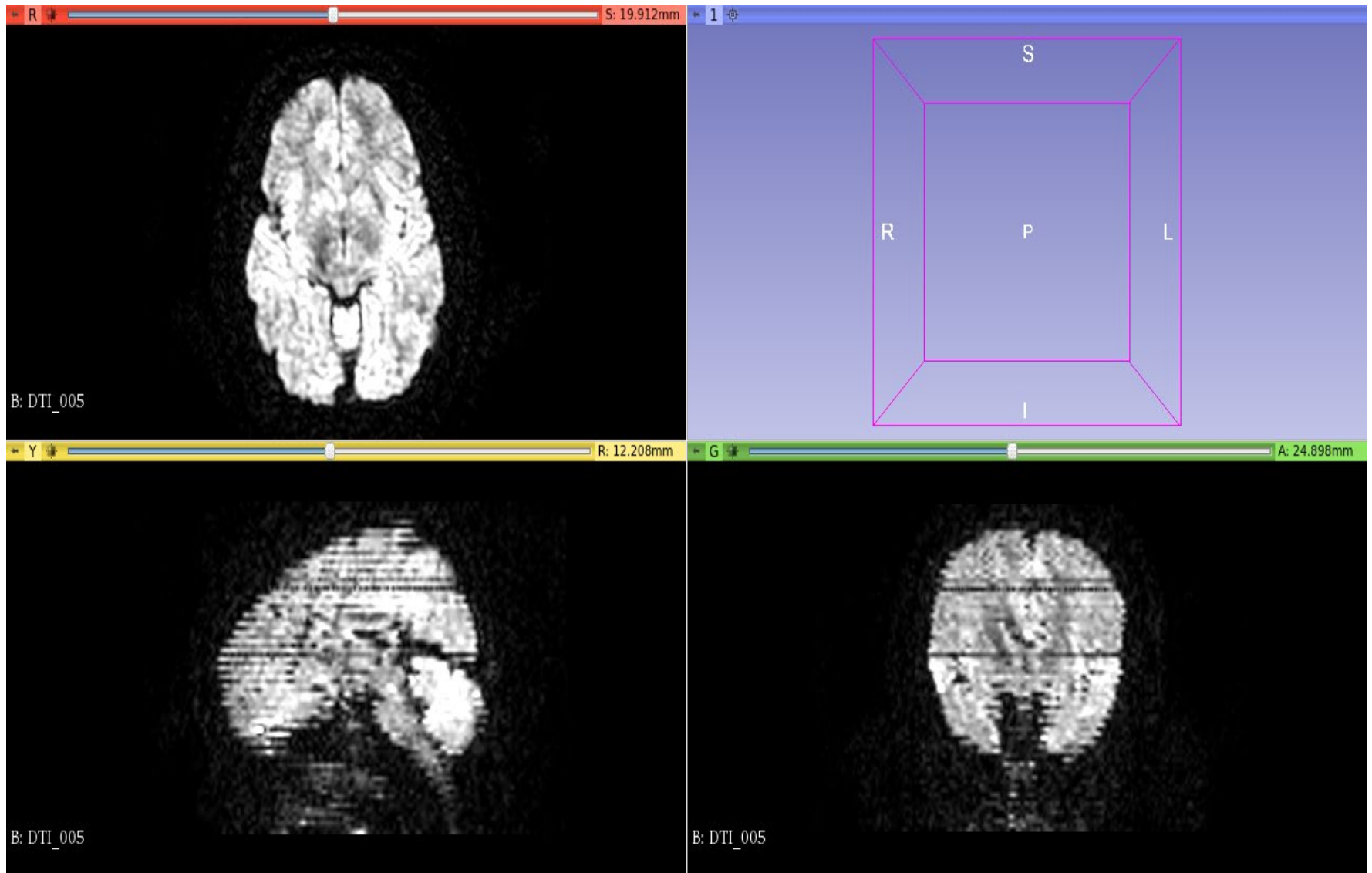
76 of 197

92 of 233

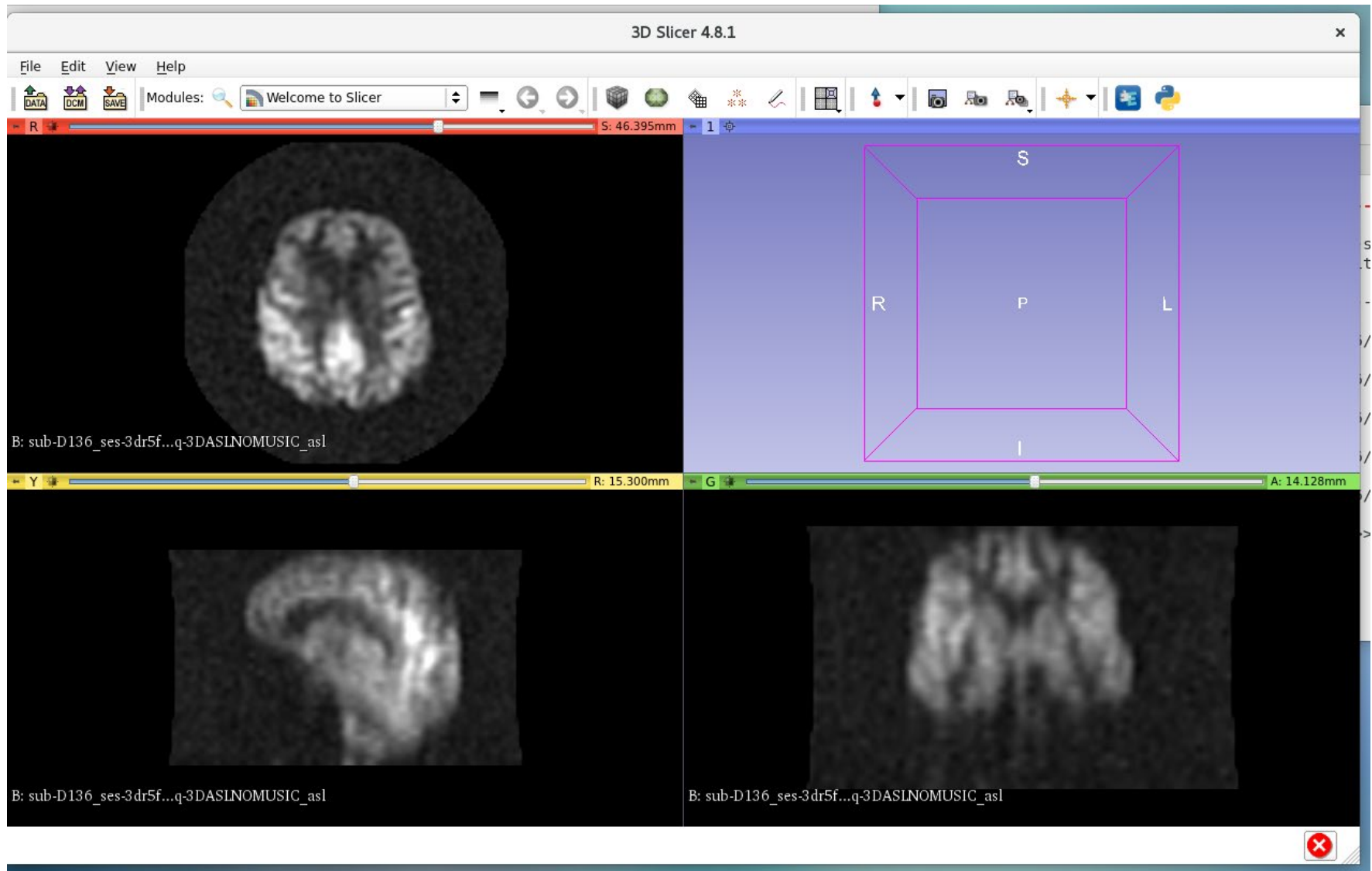
Sequences: DWI artifacts



DWI artifacts

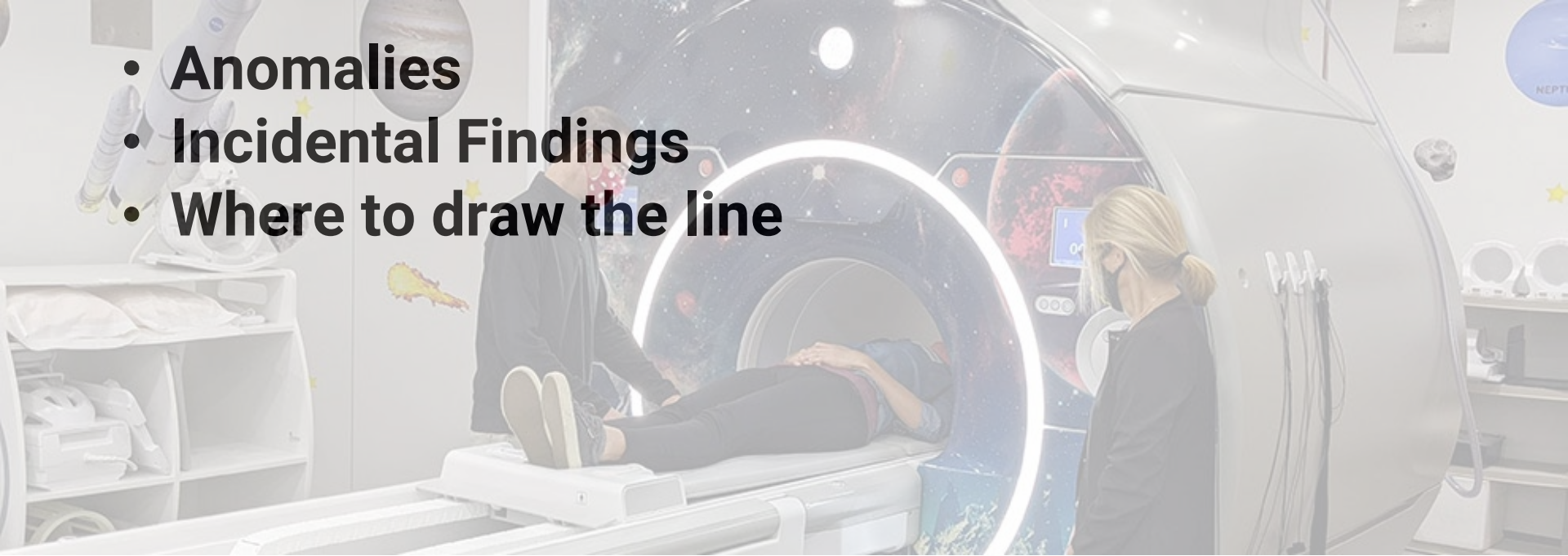


Sequences: ASL



Crazy stuff and hard cases

- **Anomalies**
- **Incidental Findings**
- **Where to draw the line**



Anomalies: Virchow–robins spaces

sub-S056_ses-3dor8s4itz_site-00201_FLAIR.nii.gz - sub-S056_ses-3dor8s4itz_label-hyperWM.nii.gz - ITK-SNAP

File Edit Segmentation Workspace Tools Help

ITK-SNAP Toolbox

Main Toolbar

Cursor Inspector

Cursor position (x,y,z):
99 117 95

Intensity under cursor:

Layer	Intensity
sub-S056_ses-3d...	636
sub-S056_ses-3...	900.9

Label under cursor:
0 Clear Label

Segmentation Labels

Active label:
Label 1

Paint over:
All labels

Overall label opacity:
0

3D Toolbar

95 of 189 zoom to fit

99 of 197 zoom to fit

117 of 233 zoom to fit

update 3D

Virchow–robins spaces FLAIR with samseg

sub-S056_ses-3dor8s4itz_site-00201_FLAIR.nii.gz - sub-S056_ses-3dor8s4itz_label-hyperWM.nii.gz - ITK-SNAP

File Edit Segmentation Workspace Tools Help

ITK-SNAP Toolbox

Main Toolbar

Cursor Inspector

Cursor position (x,y,z):
99 117 95

Layer	Intensity
sub-S056_ses-3...	636
sub-S056_ses-3d...	900.9

Label under cursor:
0 Clear Label

Segmentation Labels

Active label:
Label 1

Paint over:
All labels

Overall label opacity:
50

3D Toolbar

sub-S056_ses-3dor8s4itz_sit... A

sub-S056_ses-3dor8s4itz_sit... S

sub-S056_ses-3dor8s4itz_sit... S

10 cm

10 cm

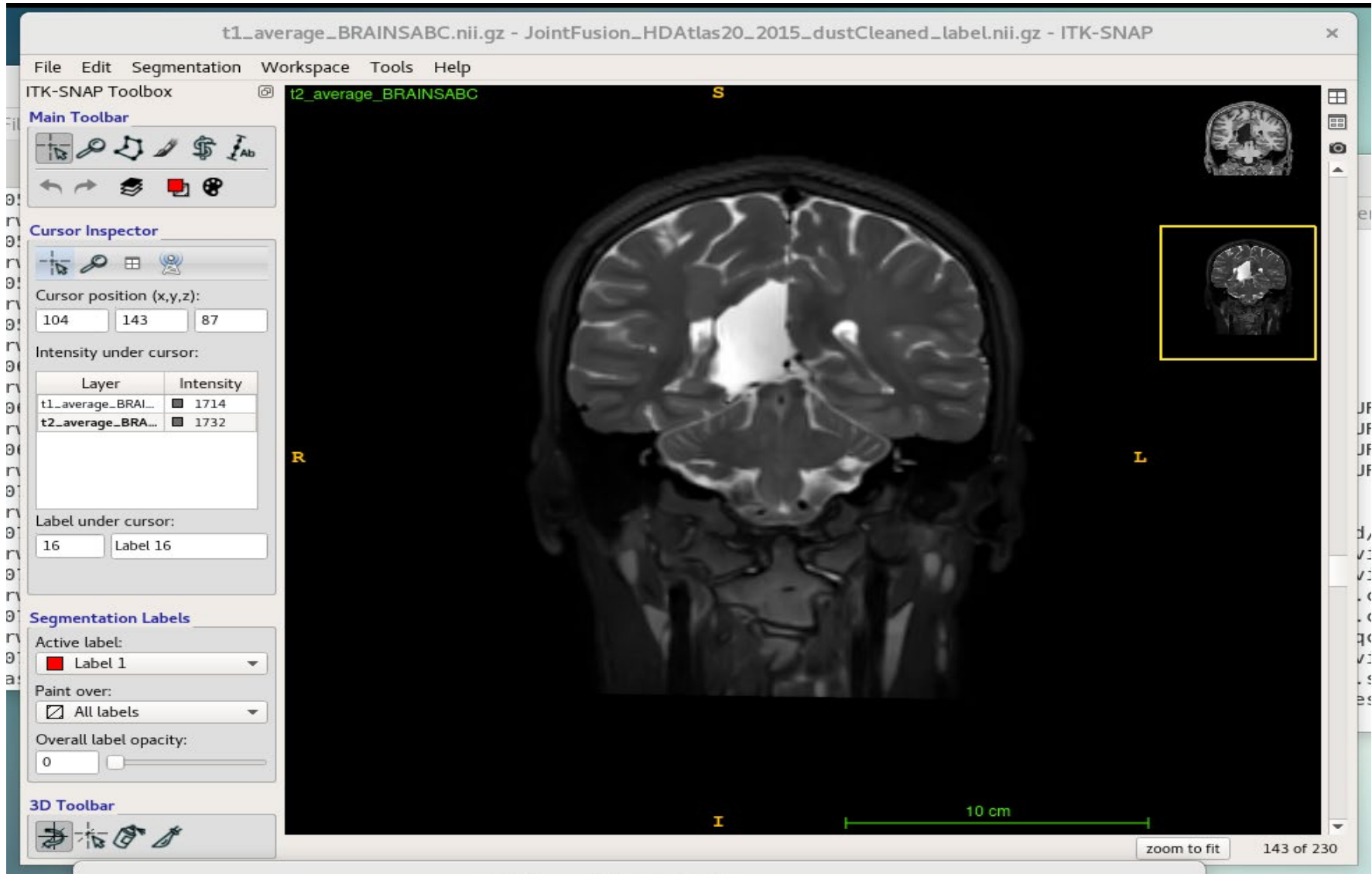
10 cm

zoom to fit 95 of 189

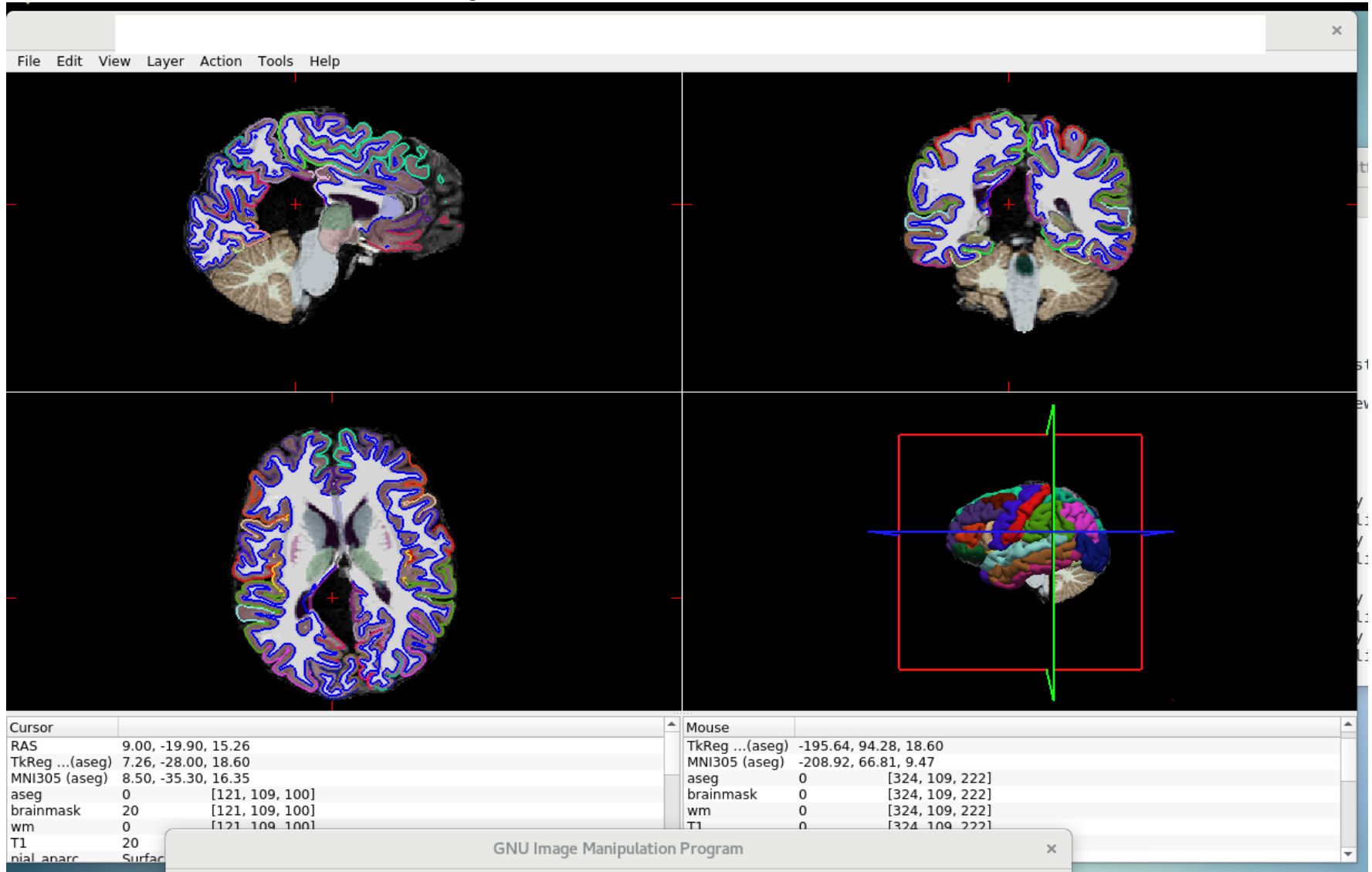
zoom to fit 99 of 197

update 3D zoom to fit 117 of 233

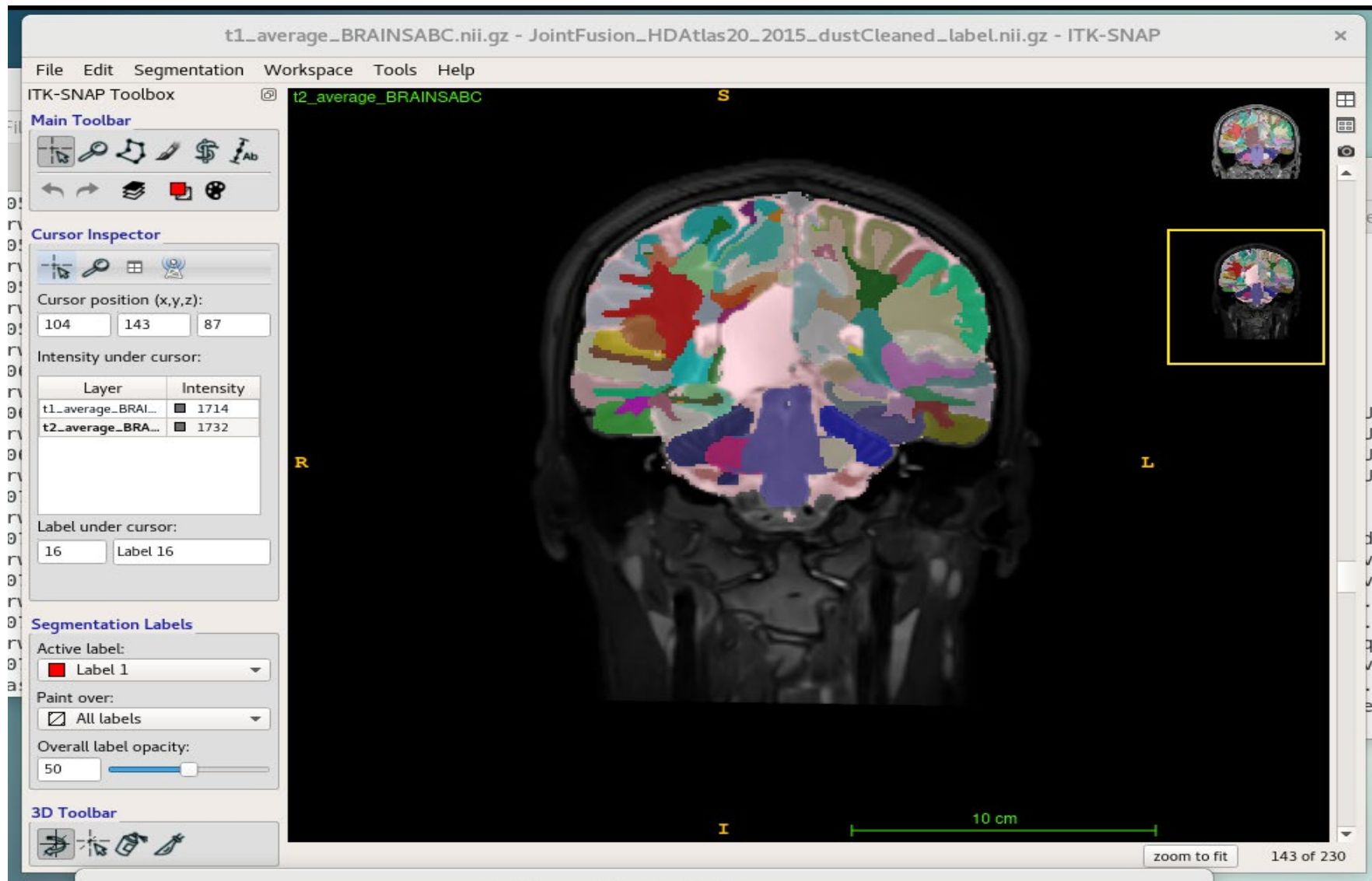
Incidental Findings: Cyst on T2



Cyst in FreeSurfer

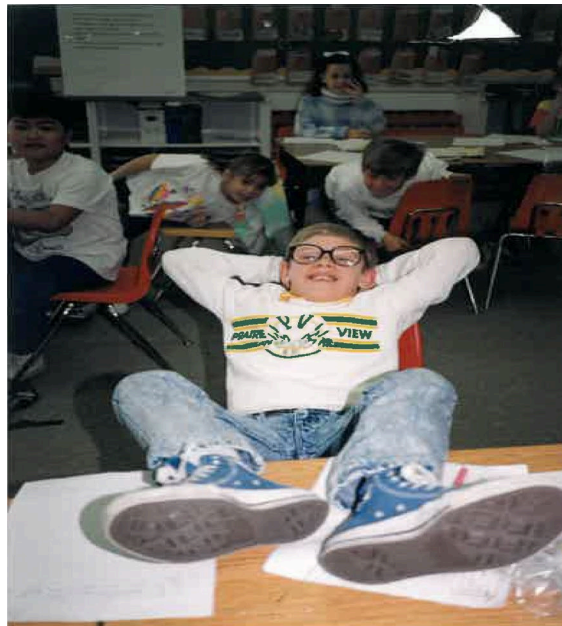


Cyst in BAW



Where to draw the line

- QC is more an art than a science
- Let your research questions guide your QC
- Every tool, pipeline, and algorithm has flaws so its determining what you are willing to except
- When in doubt flag it
- QC should improve methods development, data analysis, findings, and publications
- Take a break



Questions?

