3D Slicer for DCE-MRI Image Analysis

Madeline Carr – mec640@uowmail.edu.au

Ingham Institute
Applied Medical Research

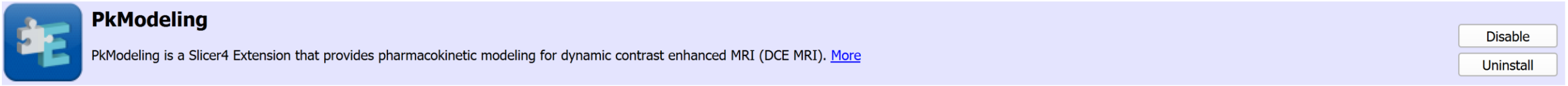
UNIVERSITY OF WOLLONGONG AUSTRALIA

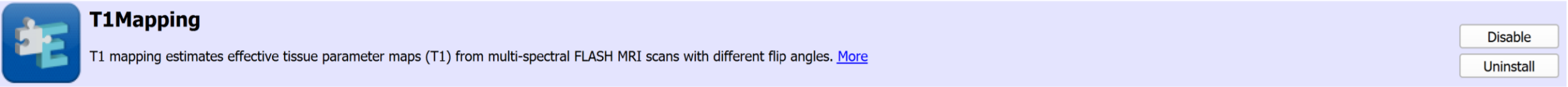
https://download.slicer.org/

Installations

*Stable version required currently to access the required modules.

- Require 2 main Extensions to be installed:
- View → Extension Manager→ Install Extensions→ Search:





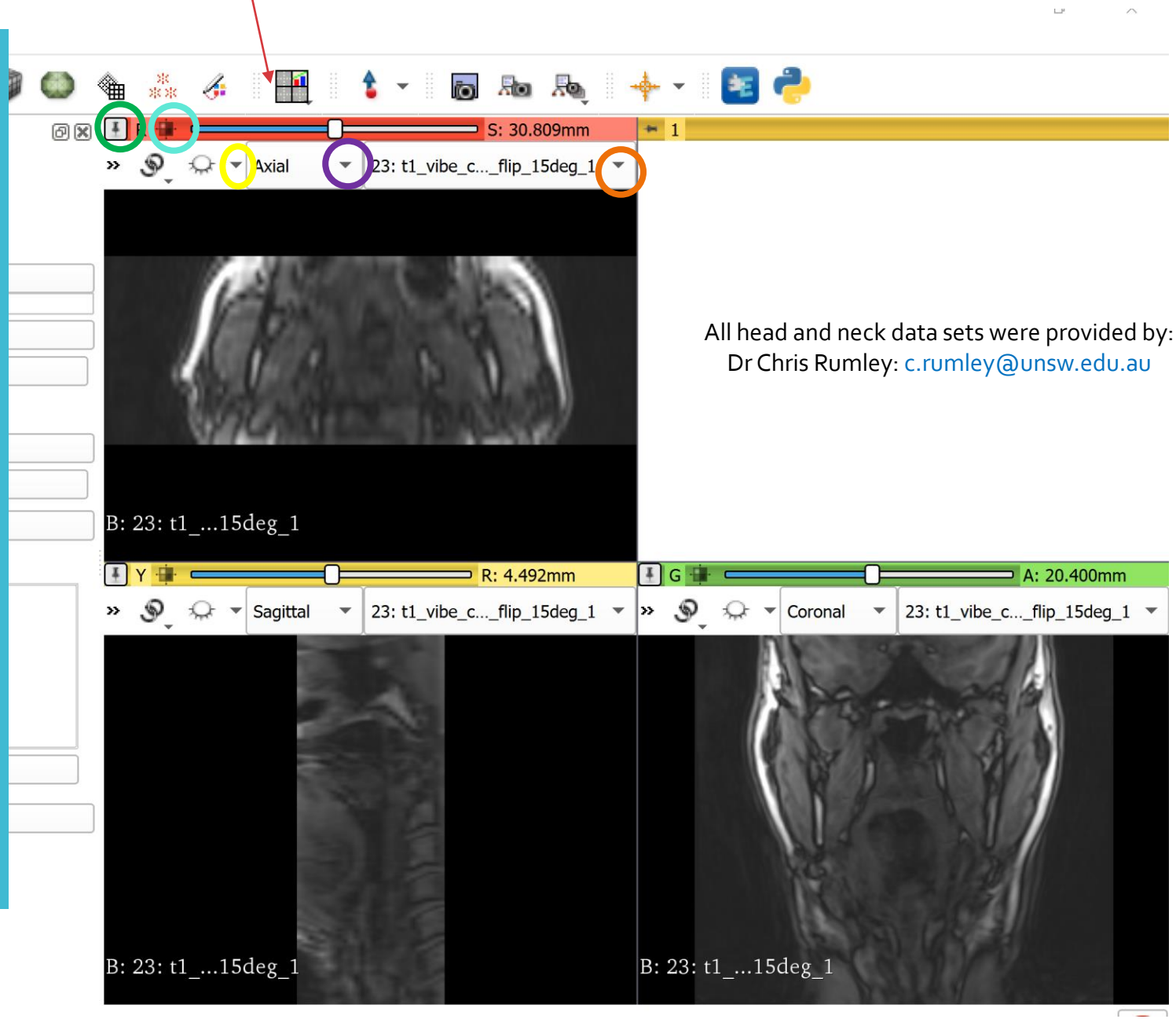
- Then restart Slicer.

Installations

Navigating

To change views below: E.g. Single or quad windows

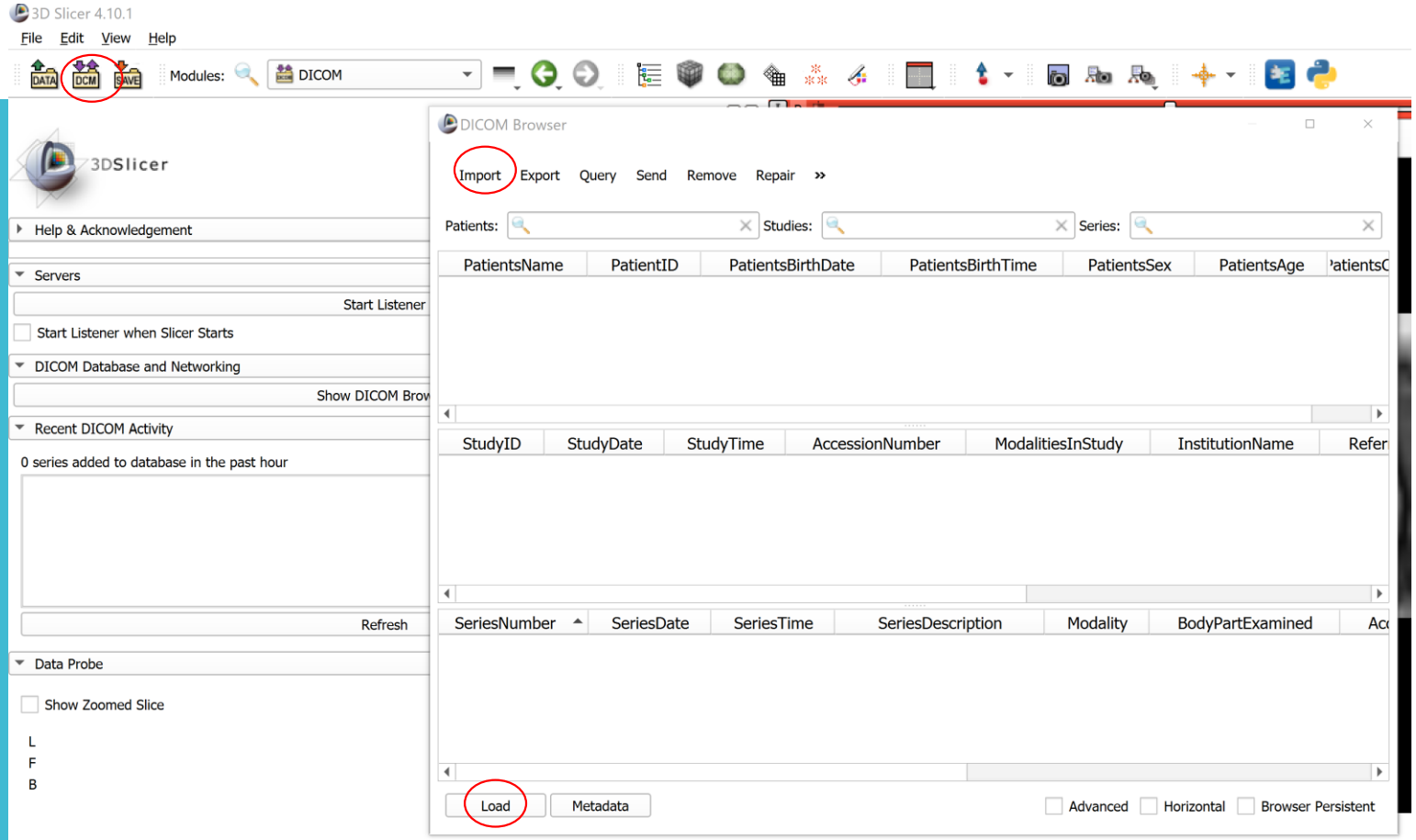
- To see image viewing options
- Change plane of observation
- Change image data set observing
- Centre image
- Set background and foreground preferences



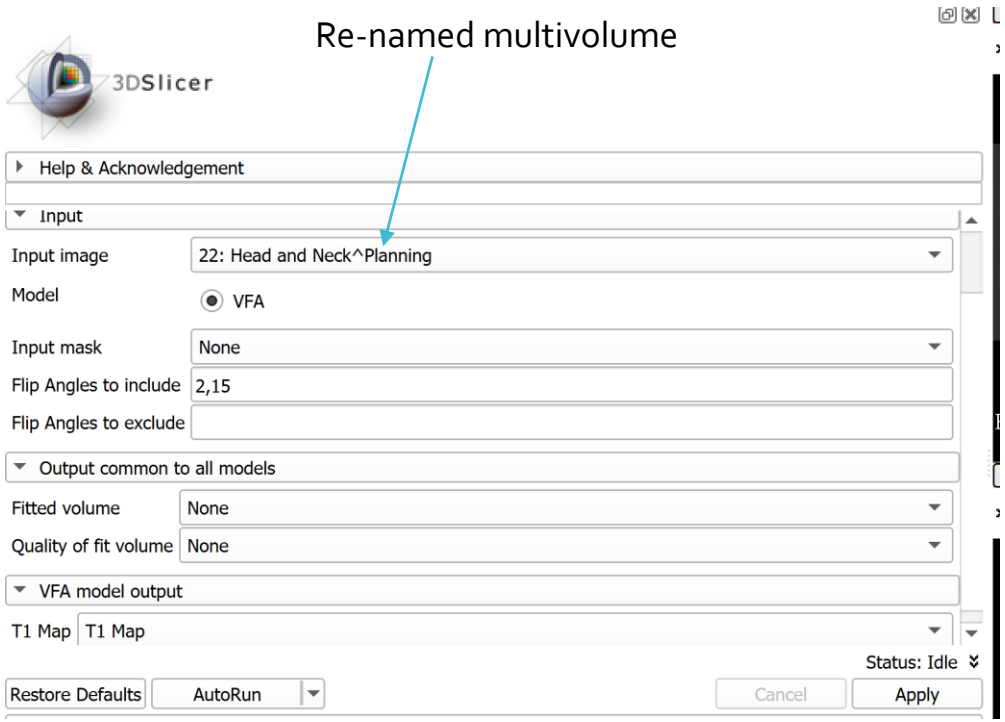
All head and neck data sets were provided by:
Dr Chris Rumley: c.rumley@unsw.edu.au

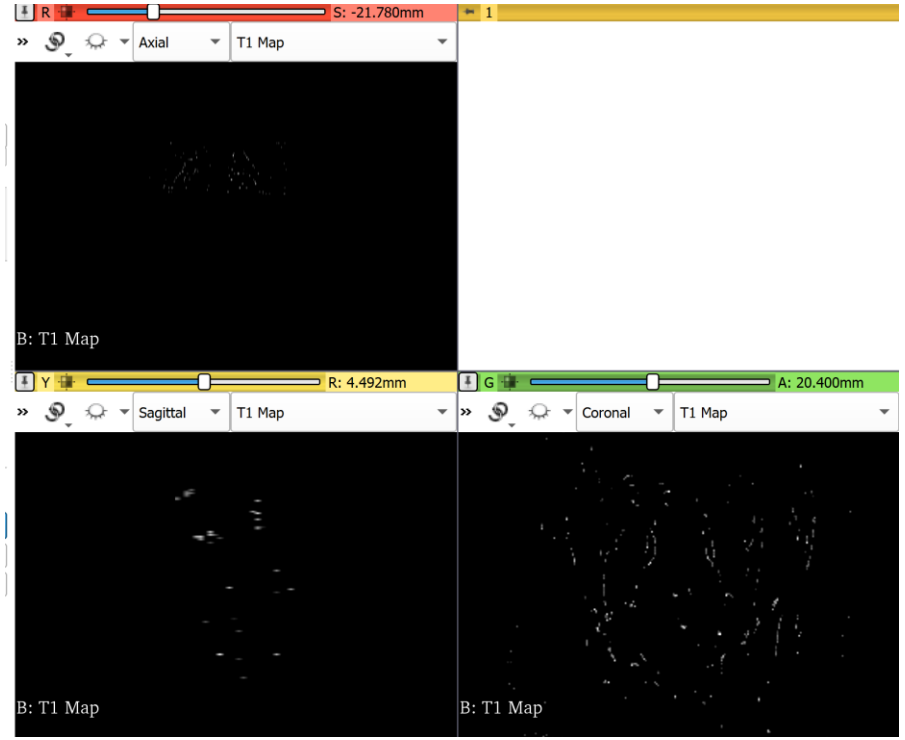
- Scroll over image to browse through slices
- Right click and scroll to zoom centrally on image
- Left click and scroll to change brightness of all images

T1-Mapping using VFA Method



- DICOM Browser→ Import: to load in VFA scan images
- Load in both flip angle scan data at the same time (select both folders)
  - This registers them together as a multi-volume; required for the T1-mapping module
  - Slicer will generally re-name the volume for you after the 'study name' in the DICOM header of the VFA scans



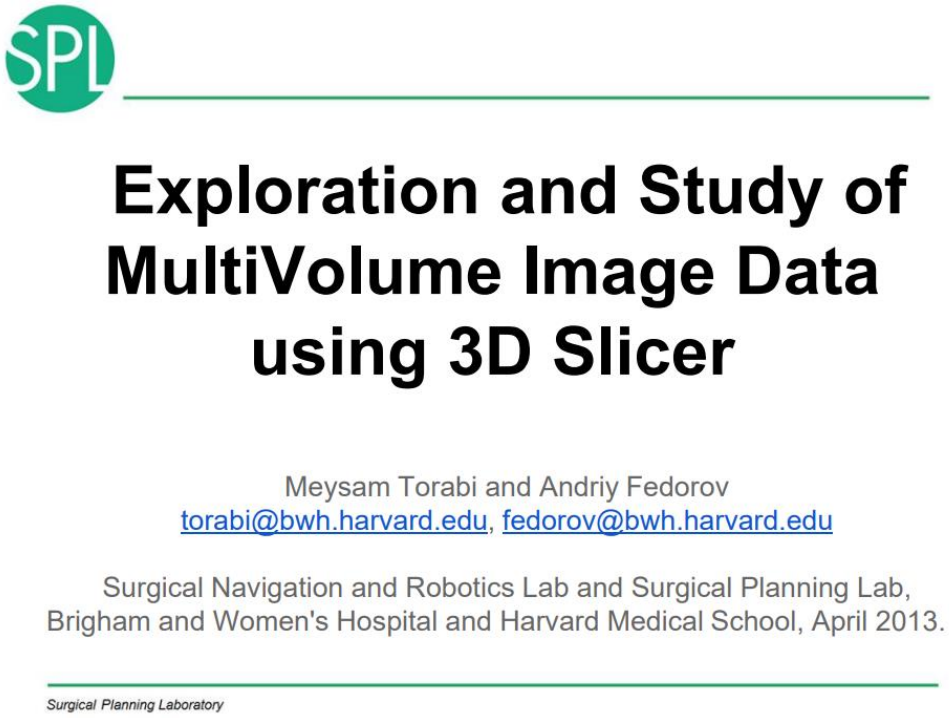


T1-Mapping

- Too see **theory** behind how this map was generated:
  - *Sung et al., 2013, Transmit B1 + Field Inhomogeneity and T1 Estimation Errors in Breast DCE-MRI at 3T*

- Input image: Must be in multi-volume format
- Model: VFA
- Type in FA's used, commas to separate
- Don't enter any in exclude box
- Output T1 Map → New Volume → T1 Map
- This will generate T1 map in 3D

Handling DCE-MRI Data Sets



Exploration and Study of MultiVolume Image Data using 3D Slicer

Meysam Torabi and Andriy Fedorov
torabi@bwh.harvard.edu, fedorov@bwh.harvard.edu

Surgical Navigation and Robotics Lab and Surgical Planning Lab,
Brigham and Women's Hospital and Harvard Medical School, April 2013.

Surgical Planning Laboratory

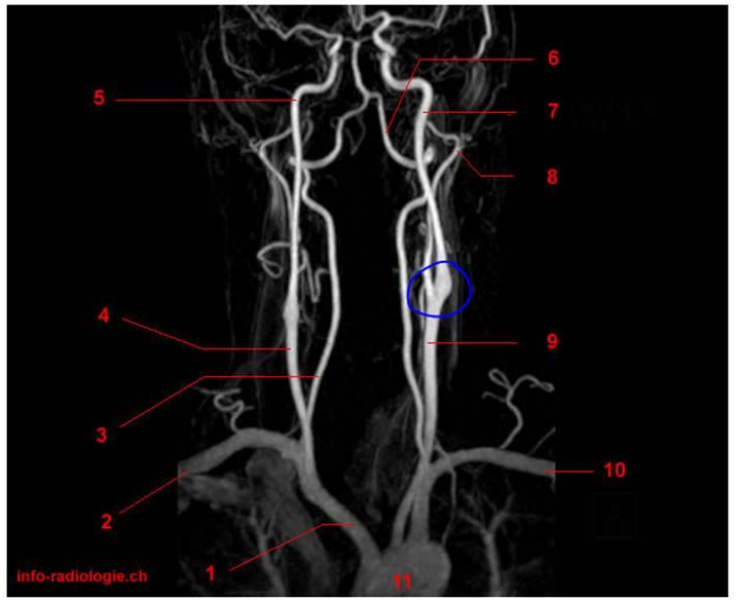
https://www.slicer.org/w/images/2/2c/MultiVolumeExplorer_Meysam_SNR-April2013-v3.pdf

- Loaded in as multi-volumes.
- To work with these, **see above slides**.

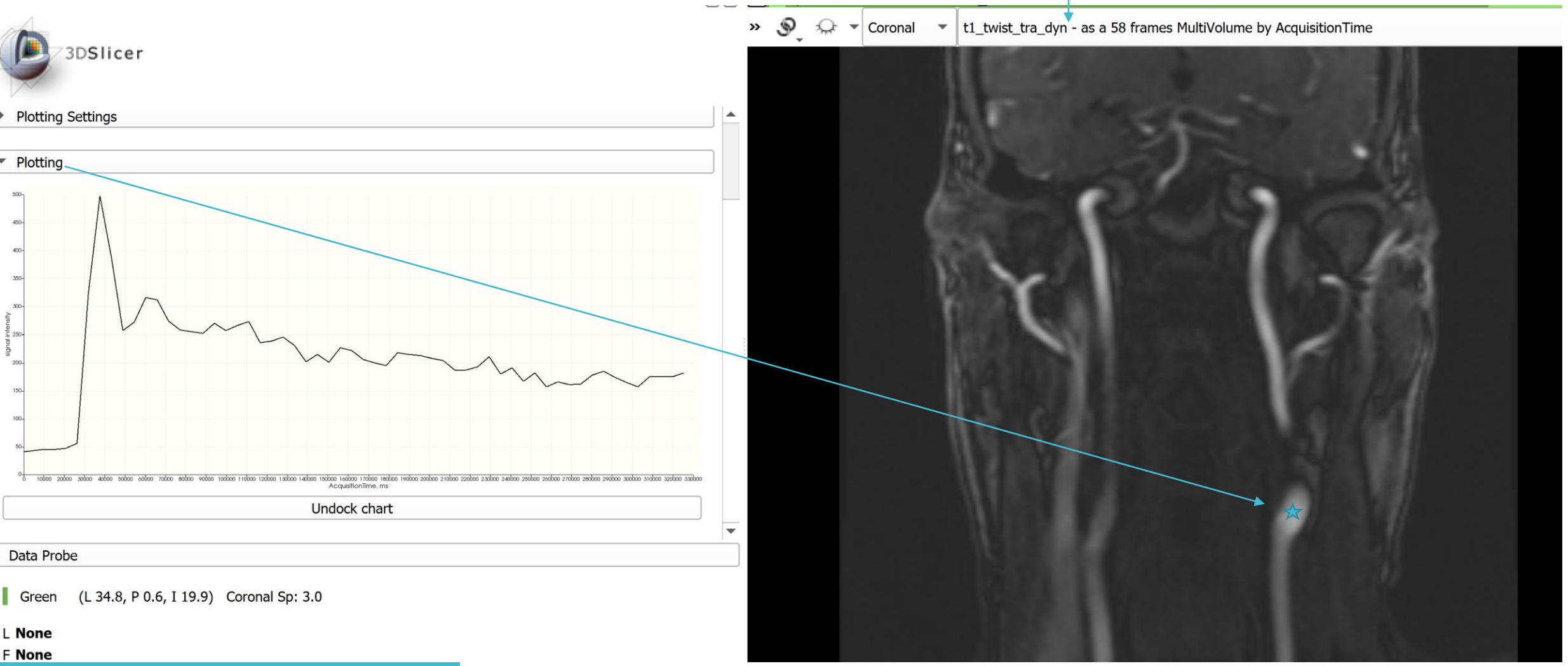
Generating an AIF

- By now, you should have:
  - Loaded in your DCE image data set
  - Made them easier to observe in appearance
  - Selected a frame for analysis in coronal plane (can do any plane though)
  - Generated a T1 Map

- The next step is generating an AIF:
  - My example will be using the carotid carotid bulb/ carotid sinus for the head and neck.
  - Need location to have rapid uptake of contrast.



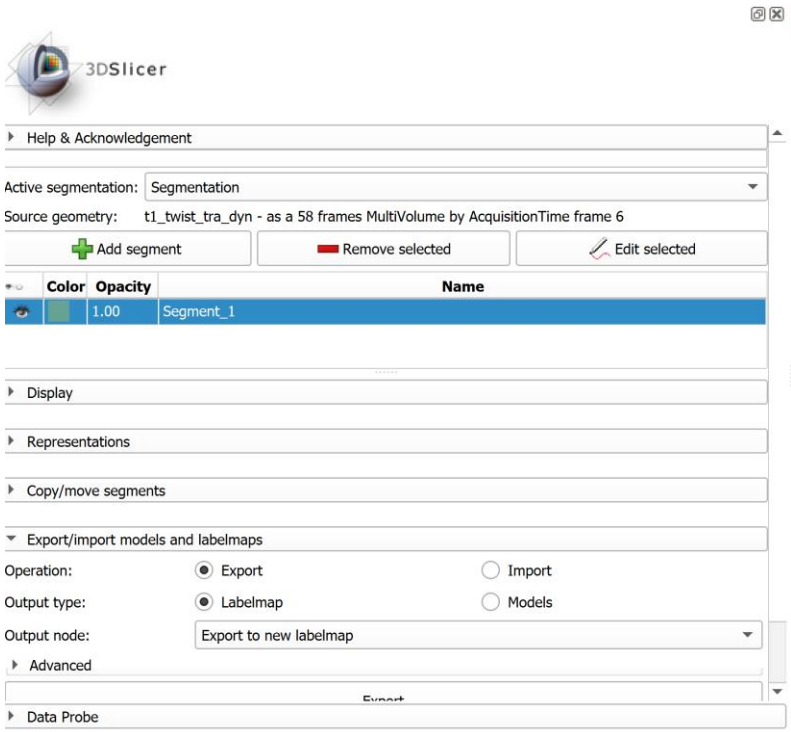
Still viewing original DCE image series

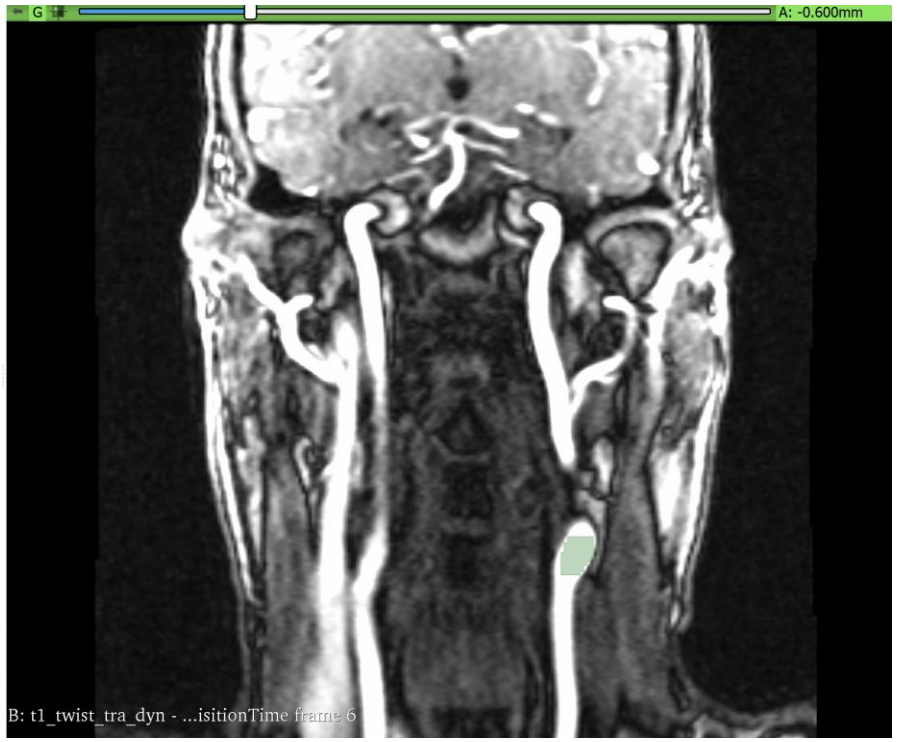


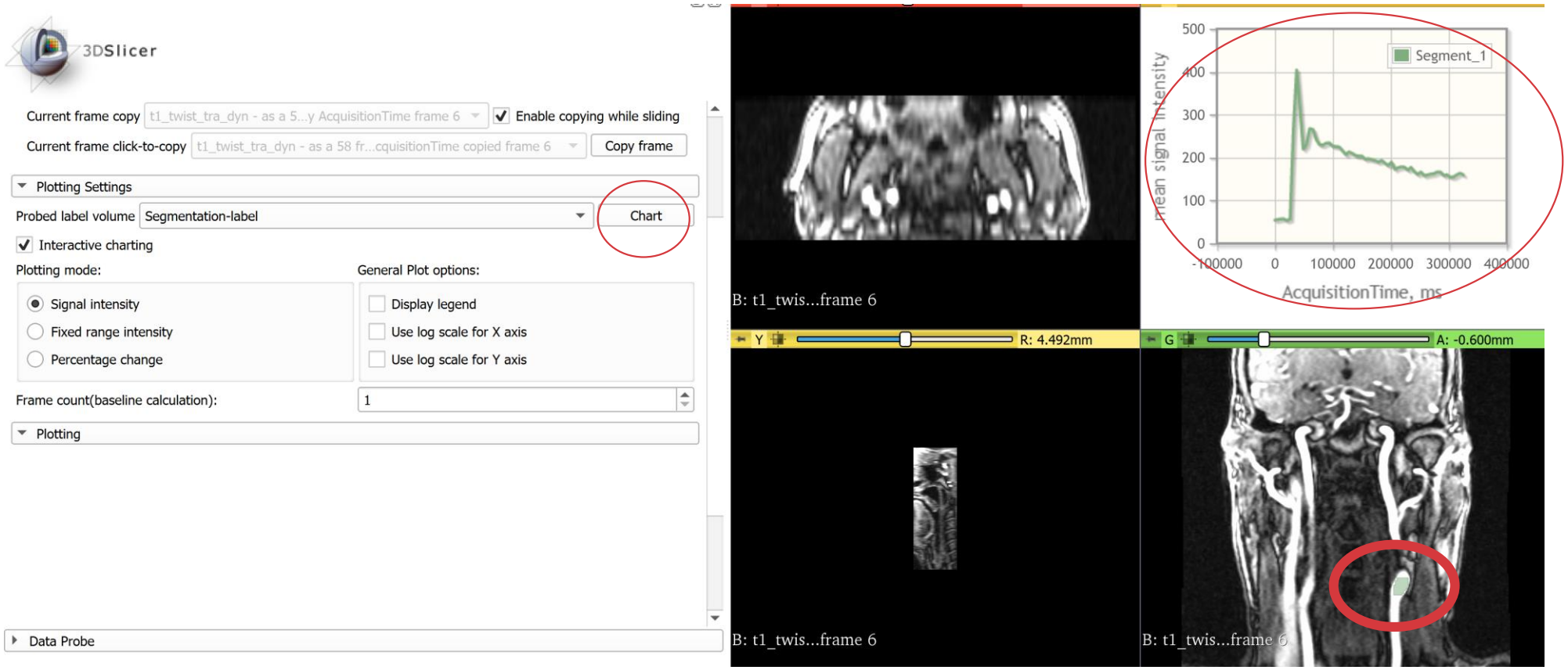
- MultiVolume Exporter→ Select DCE series at desired spatial location as Input → Select frame (should be copied already)→ Observe plot to see signal uptake vs time.

AIF Generation

- Segment Editor Module→ Select desired frame from series→ Add segment
- Use any drawing tool of choice (e.g. paint) over approx. uniform ROI that highlighted good uptake.
- *Export to new label map*







AIF Generation

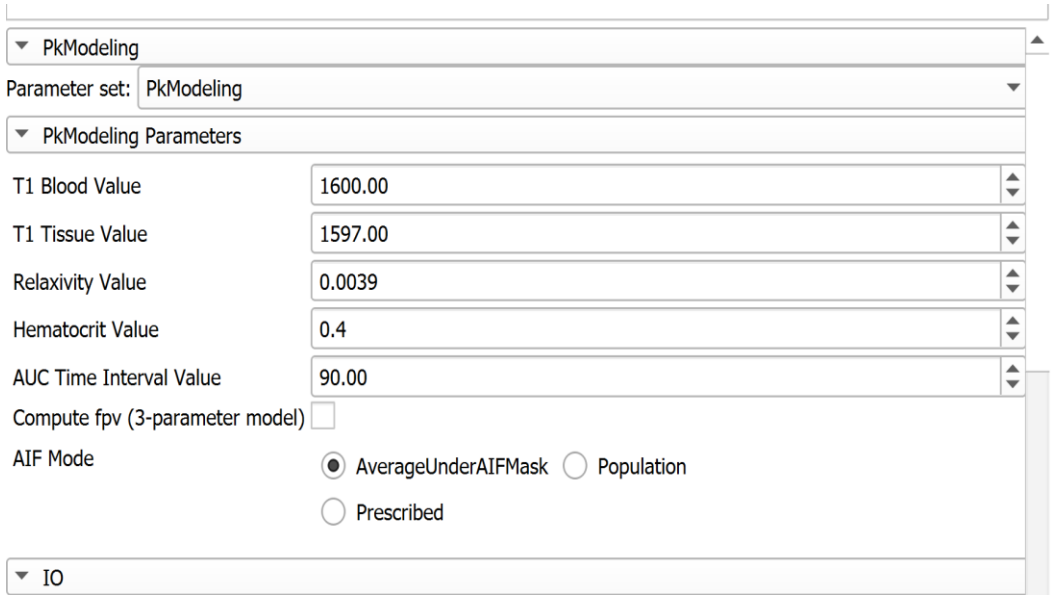
- Multivolume Exporter→ Use desired frame→ Plotting Settings
- Select your exported segmentation to be the probed label volume
- Chart
  - Easiest observation: Set viewing to 4-Up Quantitative
  - The shape of the uptake will be used as your AIF.

Now to combine all previous steps

PK-Modeling Module

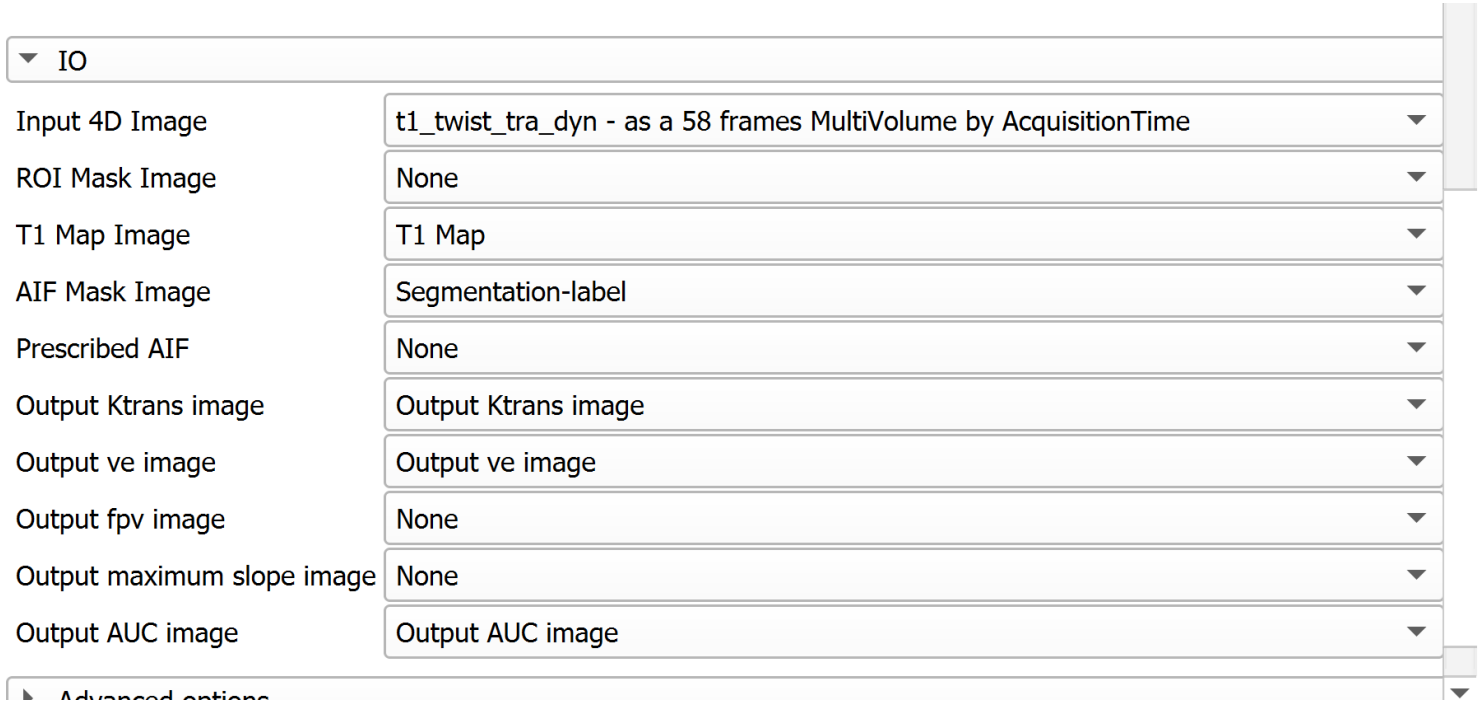
- **PKModeling Module**:

- Parameters will be auto-set to standardised prostate DCE-MRI parameters.
- Alter accordingly for your particular body region and contrast media.
- T1 overall tissue value will have to be estimated from your T1 Map or assumed from literature*.
- Can get individual patient haematocrit values- but generally okay to use a population standard.



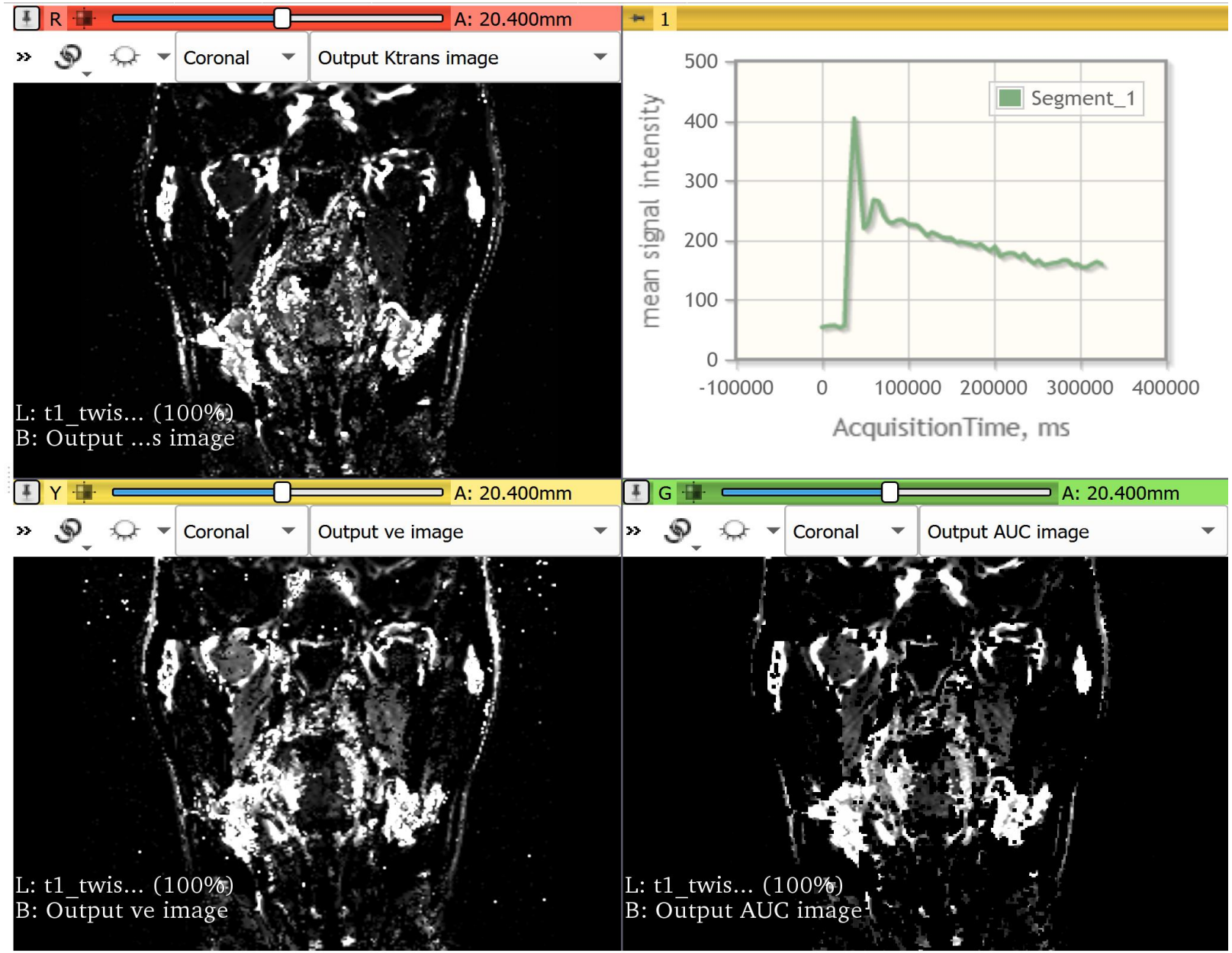
- **For AIF Mode:**
  - Select **AverageUnderAIFMask** if last step completed for segment map
  - Can use Population based for estimate but not as accurate for individual.
  - *Cont.*

PK-Modelling Module



- **Input** as above:
  - Input 4D image is your DCE-Data set
  - ROI Mask Image if you have your known ROI already (not included above)
  - Input your T1 map and Segment-label generated prior
    - If using a population based AIF, leave the AIF Mask field blank.
- **Output:** The parameter maps you desire (save each as new volume maps).

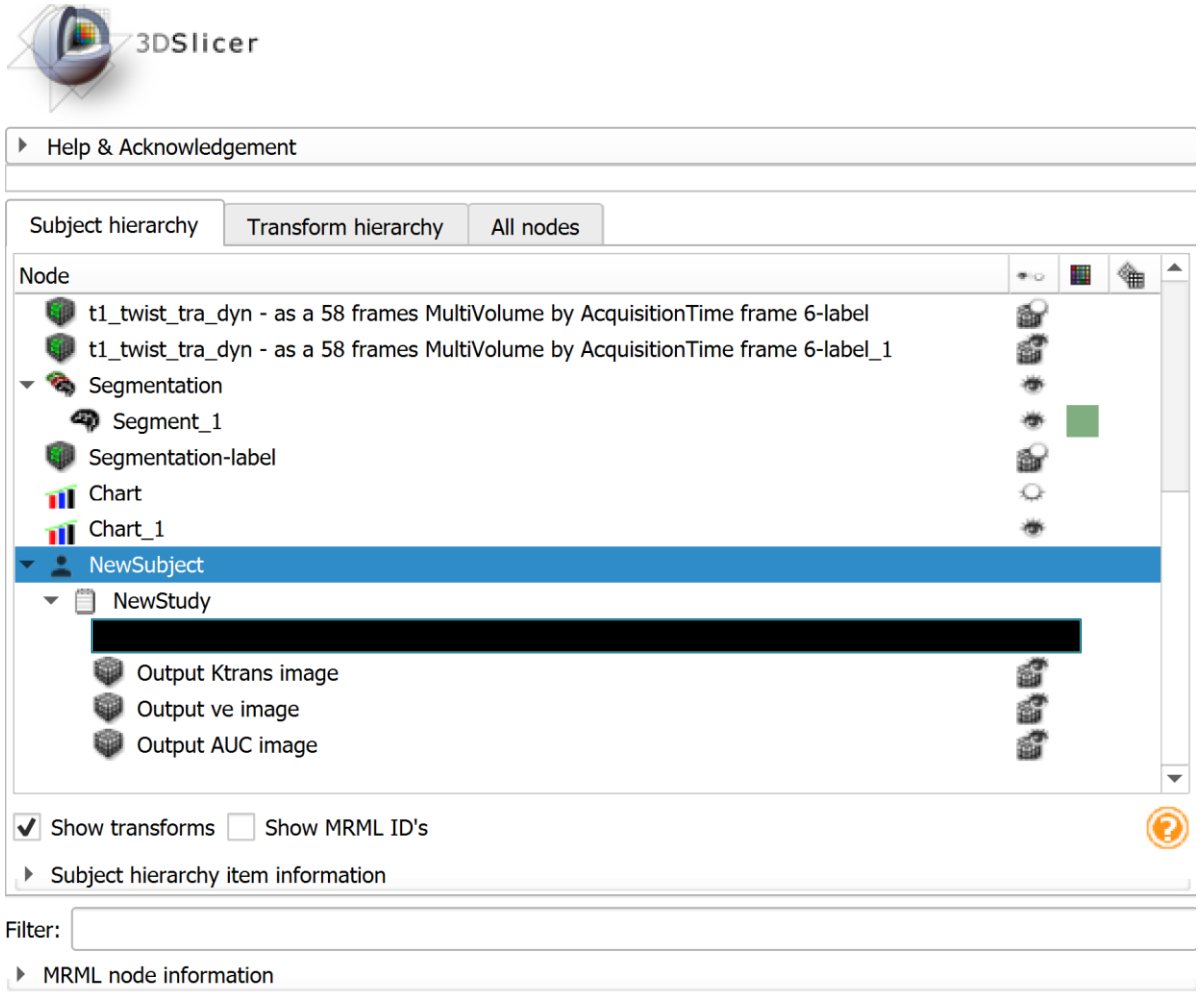
The Output


R
A: 20.400mm
Coronal
Output Ktrans image
L: t1_twis... (100%)
B: Output ...s image
1
500
400
300
200
100
0
mean signal intensity
Segment_1
-100000
0
100000
200000
300000
400000
AcquisitionTime, ms
Y
A: 20.400mm
Coronal
Output ve image
L: t1_twis... (100%)
B: Output ve image
G
A: 20.400mm
Coronal
Output AUC image
L: t1_twis... (100%)
B: Output AUC image

Exporting

- There are several exporting methods for the PK Maps:
  - Direct DICOM Export
    - Requires the Quantitative Reporting extension installed or to apply a scaling filter beforehand: Want float-point values to be conserved.
  - Nrrd (standard- recommended)
    - E.g. Using nrrd reader on MATLAB or Python for analysis.
  - MatlabBridge extension
    - MATLAB only based analysis.

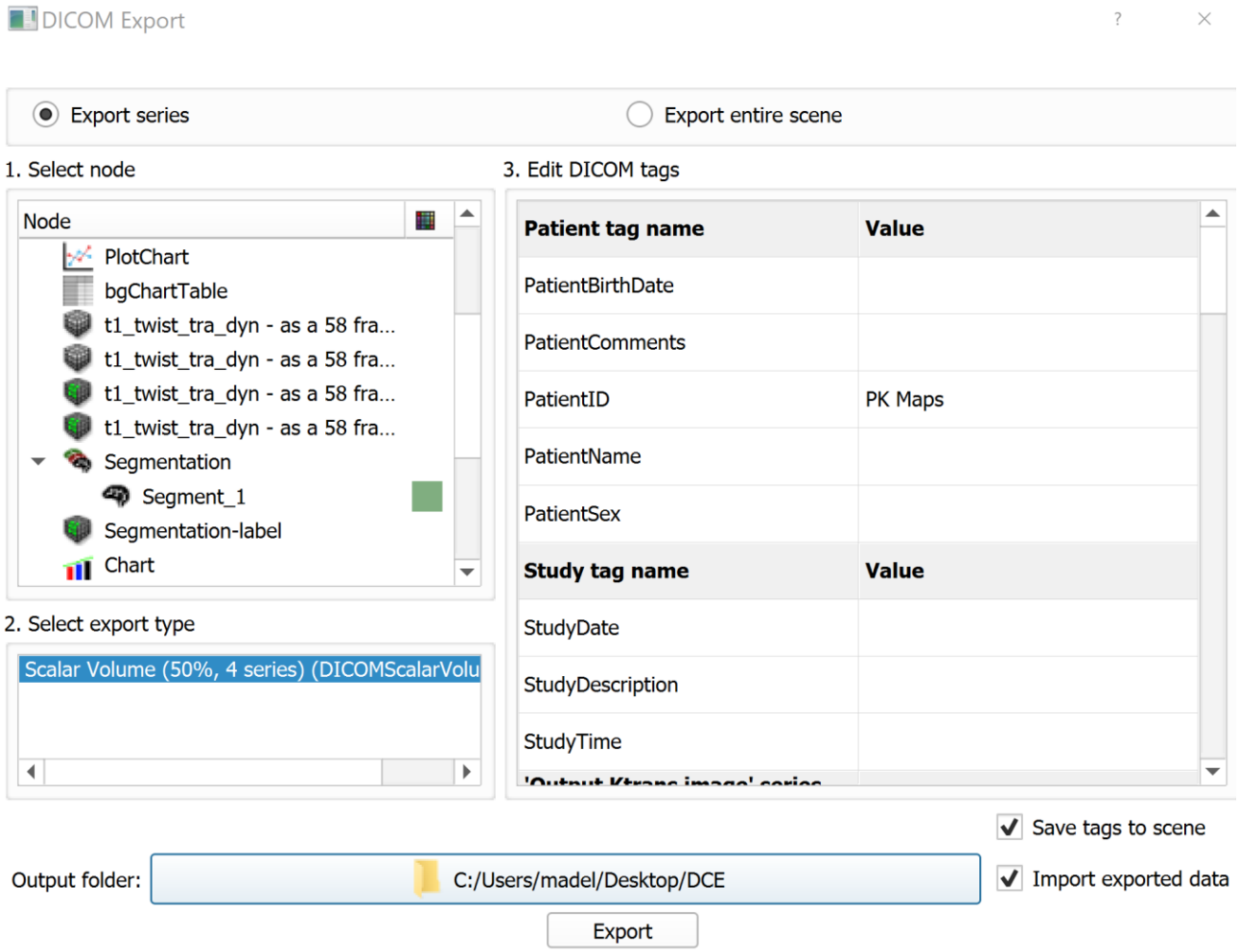
Export to DICOM



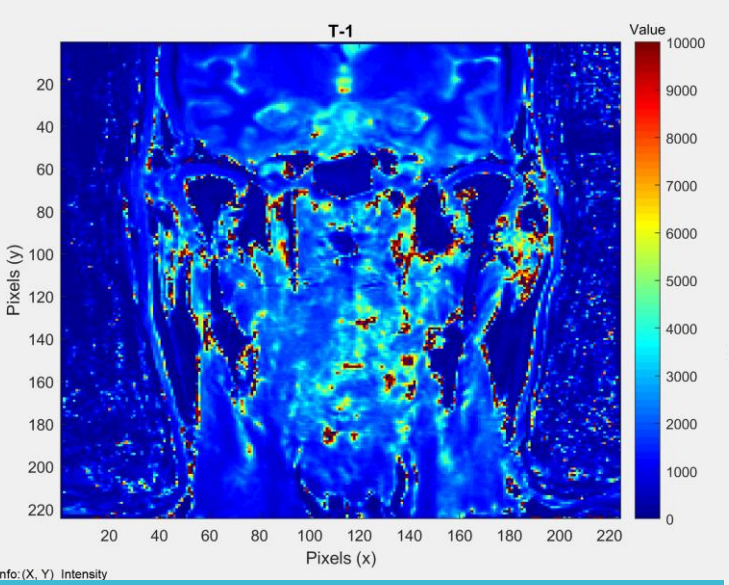
- Open: **Data Module**
- Create 'New Subject' (right click in blank space)
  - Create new 'Child Study'
  - Drag maps into 'New Study'
- Right click on the New Study→ Export to DICOM

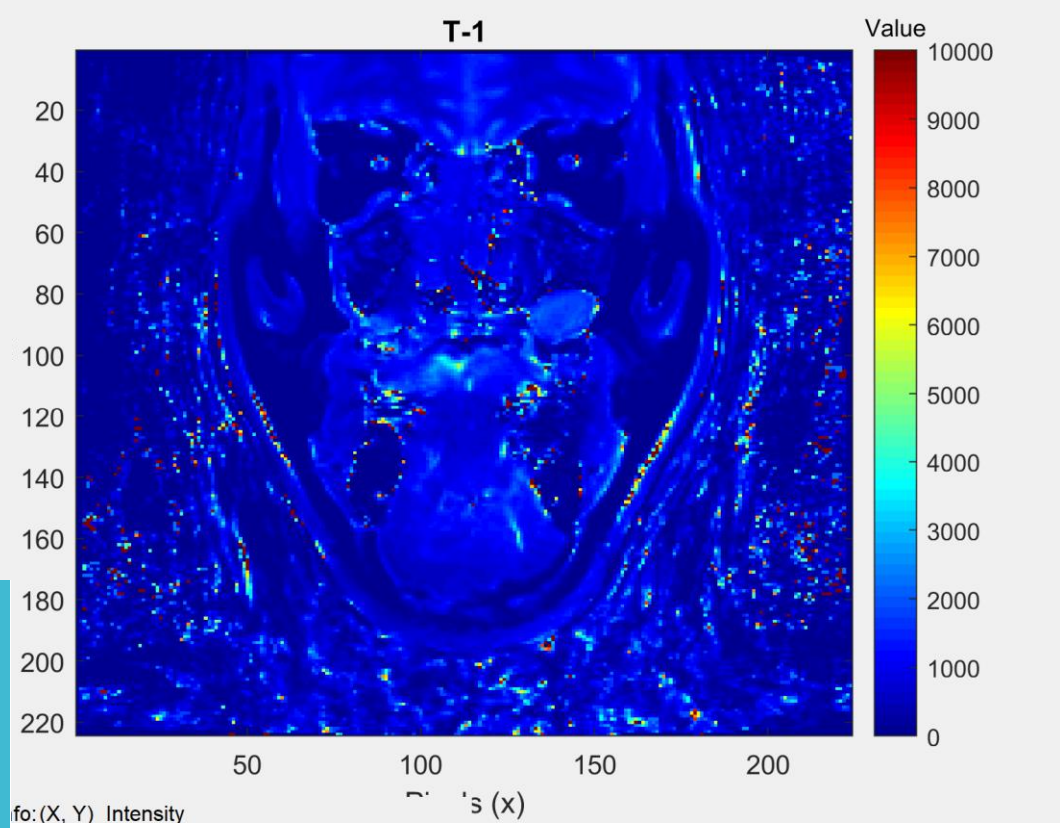
*T1-map can require a different subject→ See next 2 slides.

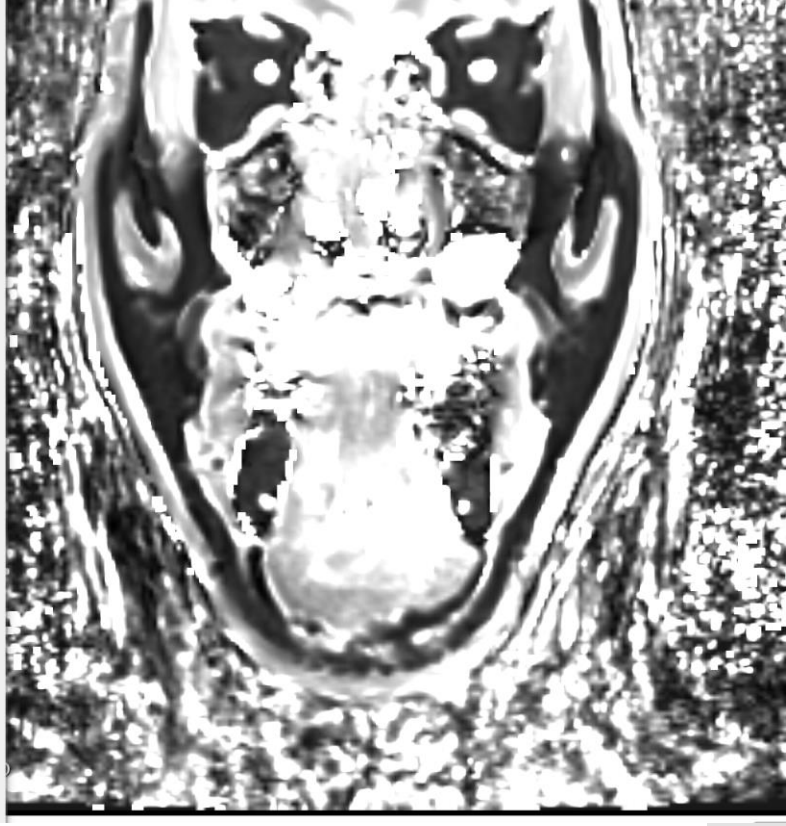
Export



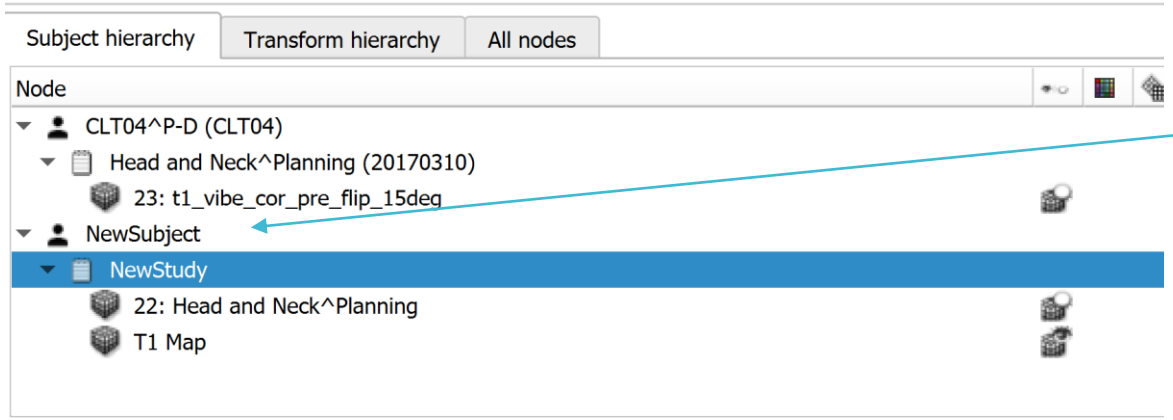
- Each parameter map in the study will be saved to a different folder.







T1-map to DICOM



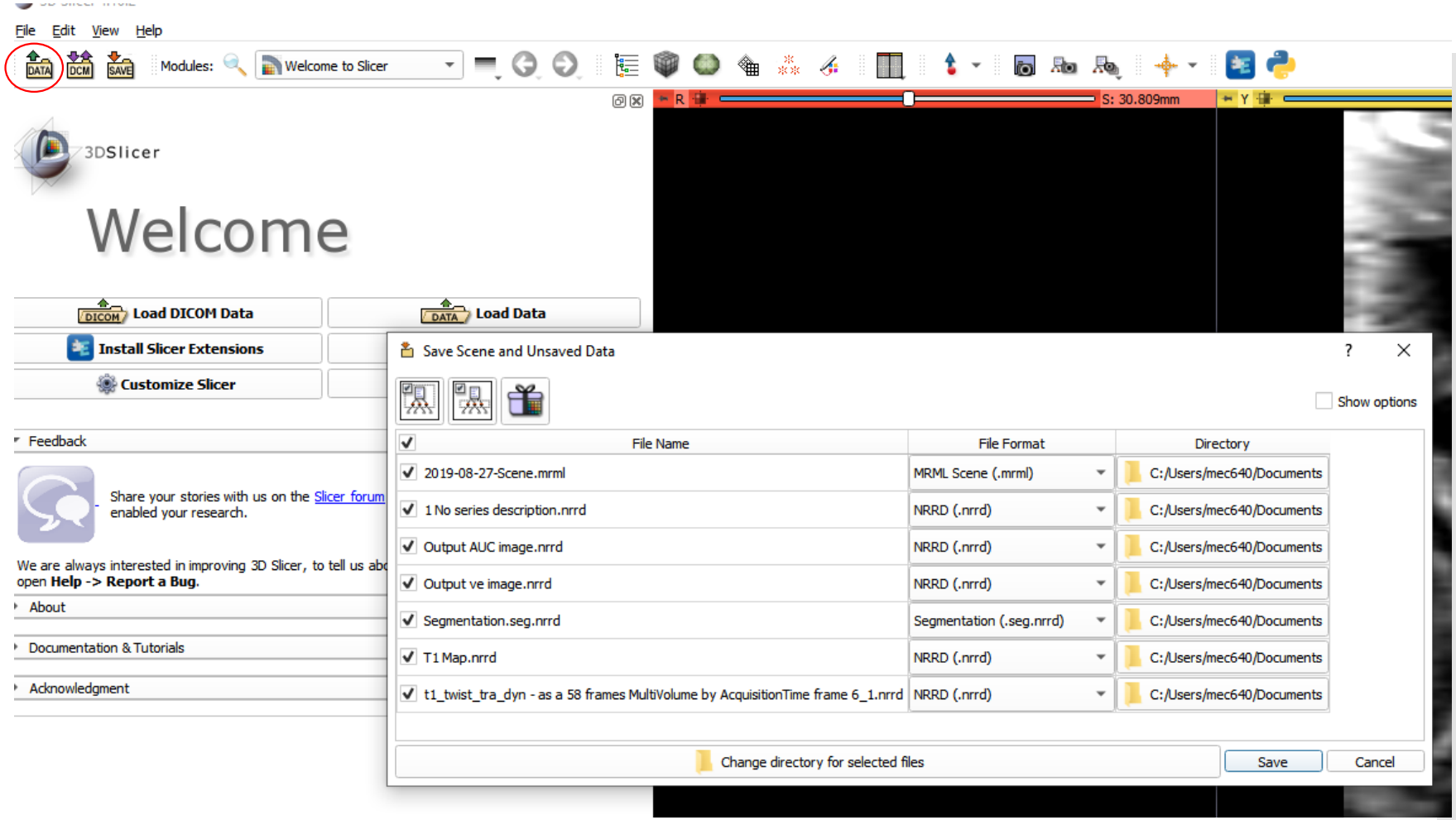
- Complete previous process with moving the T1 map to same new study as the combined VFA multivolume.

Simple MATLAB Code (DICOM)

- First open **DICOM Image Reader Application (Matlab2018+)** and export image of choice to the workspace (e.g. as 't1'). Then use:

```
figure;
  imagesc(t1)
 title(['T-1'])
 hi=colorbar('eastoutside');
 k = jet(7);
 colormap('jet');
 title(hi,'Value')
 caxis([0 10000]);
 xlabel('Pixels (x)') % x-axis label
 ylabel('Pixels (y)') % y-axis label
impixelinfo()
 m = mean(t1(:));
disp(m)
```

Export to nrrd



- Save scenes as nrrd files:
  - Allows you to work on them again on Slicer directly
  - Easily opened by MATLAB and Python

https://github.com/PerkLab/SlicerMatlabBridge/blob/master/MatlabCommander/commandserver/nrrdread.m

Simple MATLAB Code (nrrd)

- Download nrrdread.m and then call the function using your image data set:

```
image = nrrdread('Output ve image.nrrd')
 T_matrix =[224 224 26]; %[height width #slices]
 M1 = repmat(single(0), T_matrix);

 for m1 = 1:26
   M1(:,:,:) = image.pixelData();
 End

 for F =1:26
   imshow3D(M1)
   title([‘Slice #', num2str(F)])
   hi=colorbar('eastoutside');
   k = jet(7);
   colormap('jet');
   title(hi,‘PK Map')
   caxis([0 2]);
   xlabel('Pixels (x)') % x-axis label
   ylabel('Pixels (y)') % y-axis label
 end
```