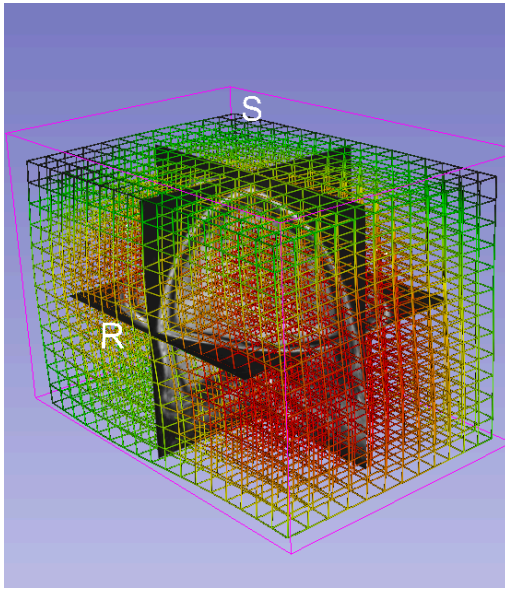


Image Registration Tutorial

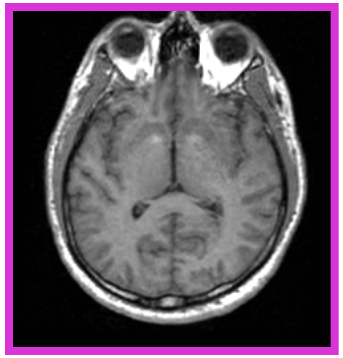
Sonia Pujol, Ph.D. Dominik Meier, Ph.D., Ron Kikinis, M.D.

Surgical Planning Laboratory

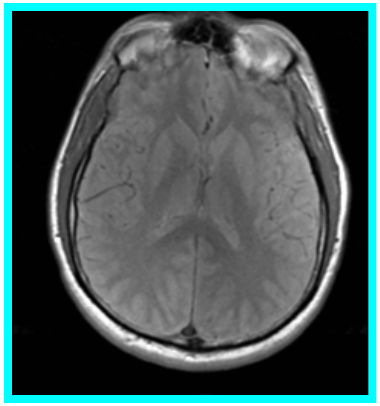
Brigham and Women's Hospital

Harvard Medical School

Motivation



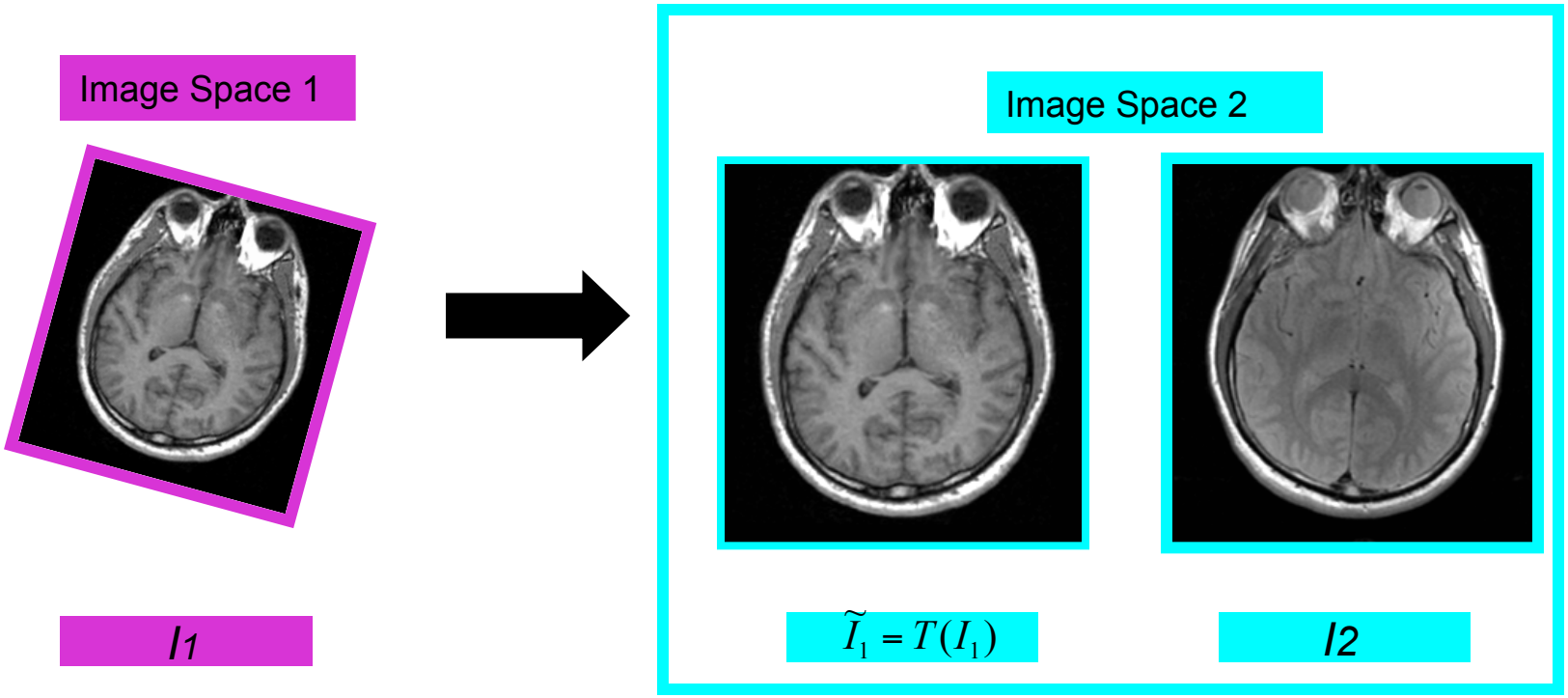
Dataset 1



Dataset 2

Registration algorithms bring multiple image data sets into spatial alignment, in order to achieve **anatomical agreement**.

Apply the registration transform

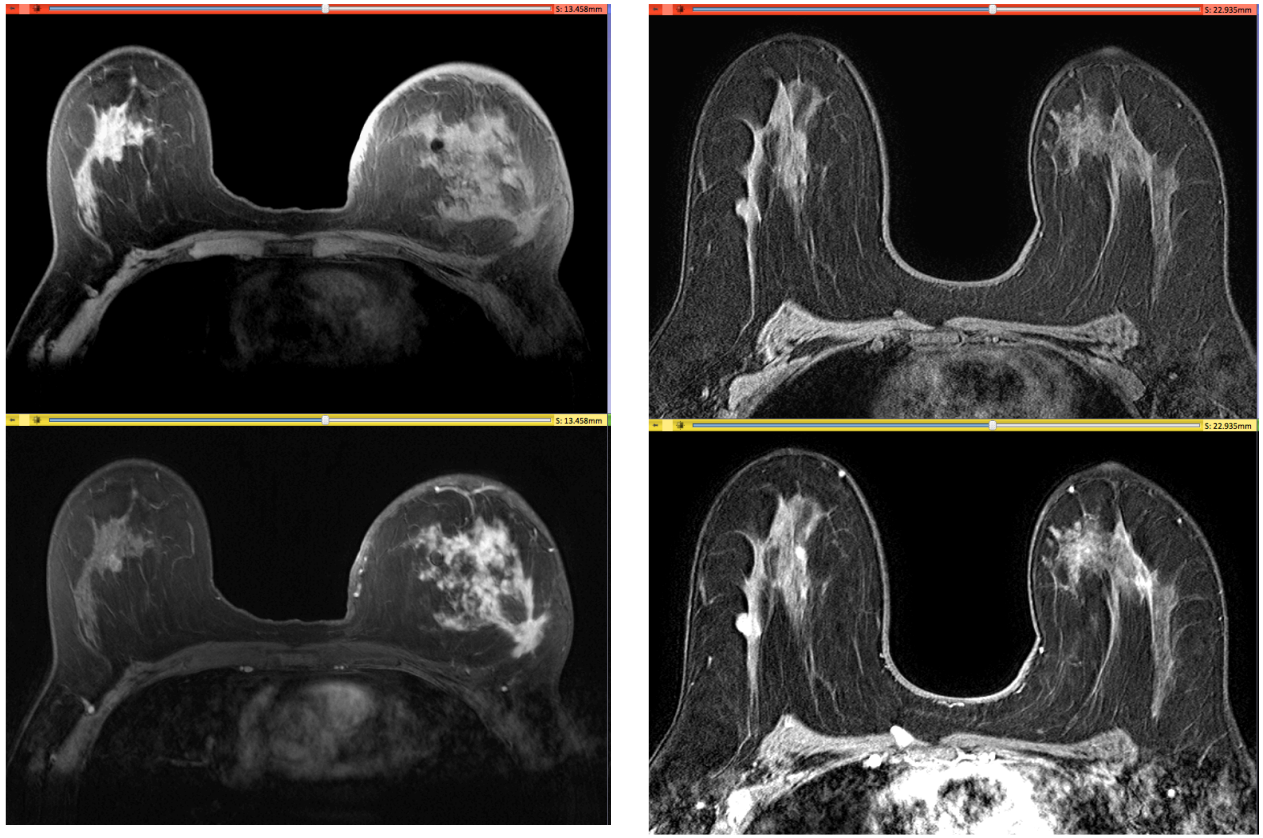


By applying the registration transform to the initial volume *I1,* we can generate a new volume T(*I1)* spatially aligned with the volume *I2.*

$\tilde{I}_1$

This allows the extraction of quantitative information from the two volumes.

Example 1: Large volumetric change between two time points



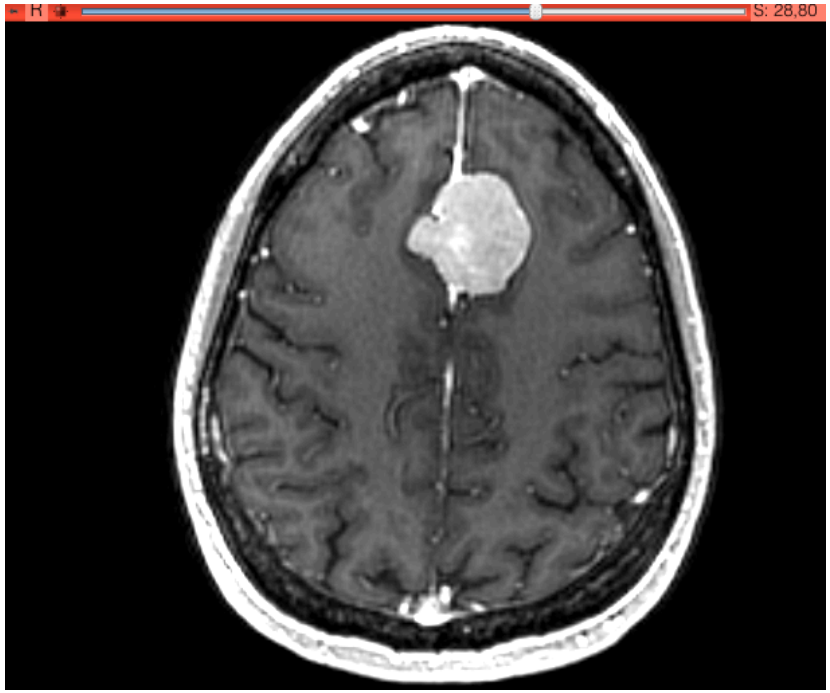
Pre-therapy

Post-therapy

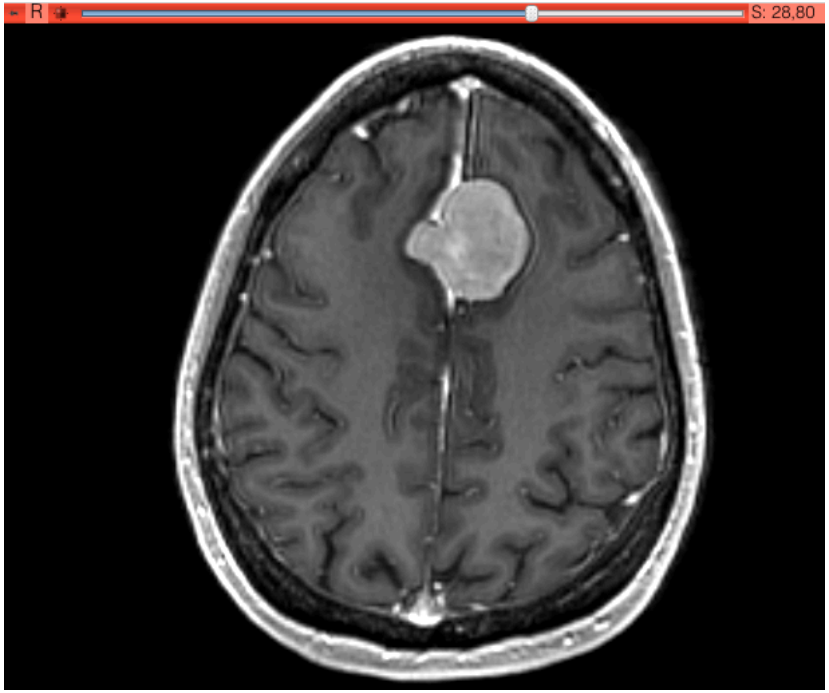
Infiltrating ductal carcinoma

Data Courtesy of Dr. Katarzyna Macura, JHU

Example 2: Small volumetric change



MR Scan1 June 2006



MR Scan2 June 2007

Meningioma

Objective of the tutorial

- Guiding you step-by-step through the process of automatically registering two structural MR datasets acquired on two different subjects using rigid and non-rigid registration

- This tutorial is built upon the Registration Case Libray 31 tutorial available at

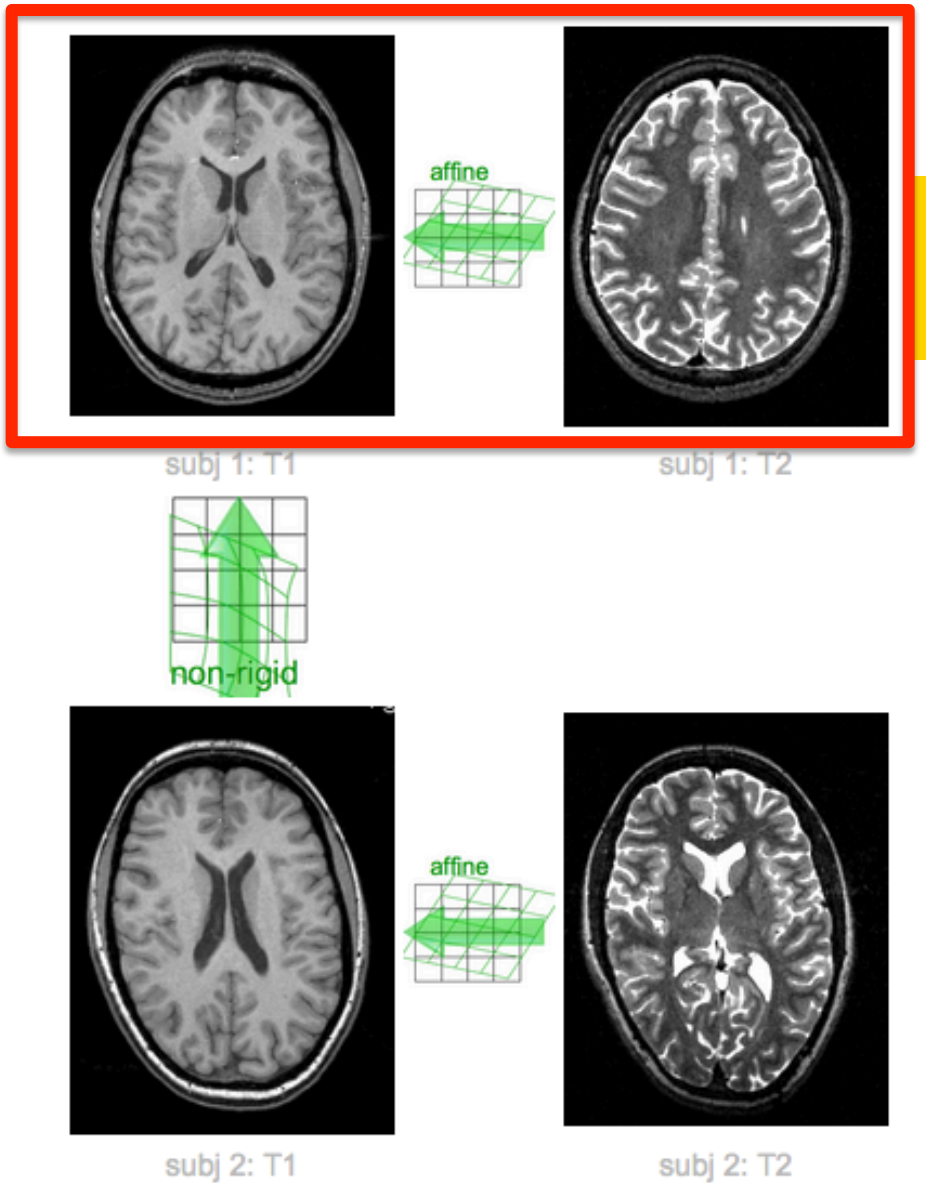
http://www.na-mic.org/Wiki/index.php/Projects:RegistrationLibrary:RegLib_C19

Tutorial Dataset

- The dataset includes two T1-weighted and T2-weighted MR scans acquired on two healthy subjects.

- The dataset is Registration Case 19 of the NA-MIC registration case library (P.I. Dr. Dominik Meier, Ph.D.)

Registration pipeline

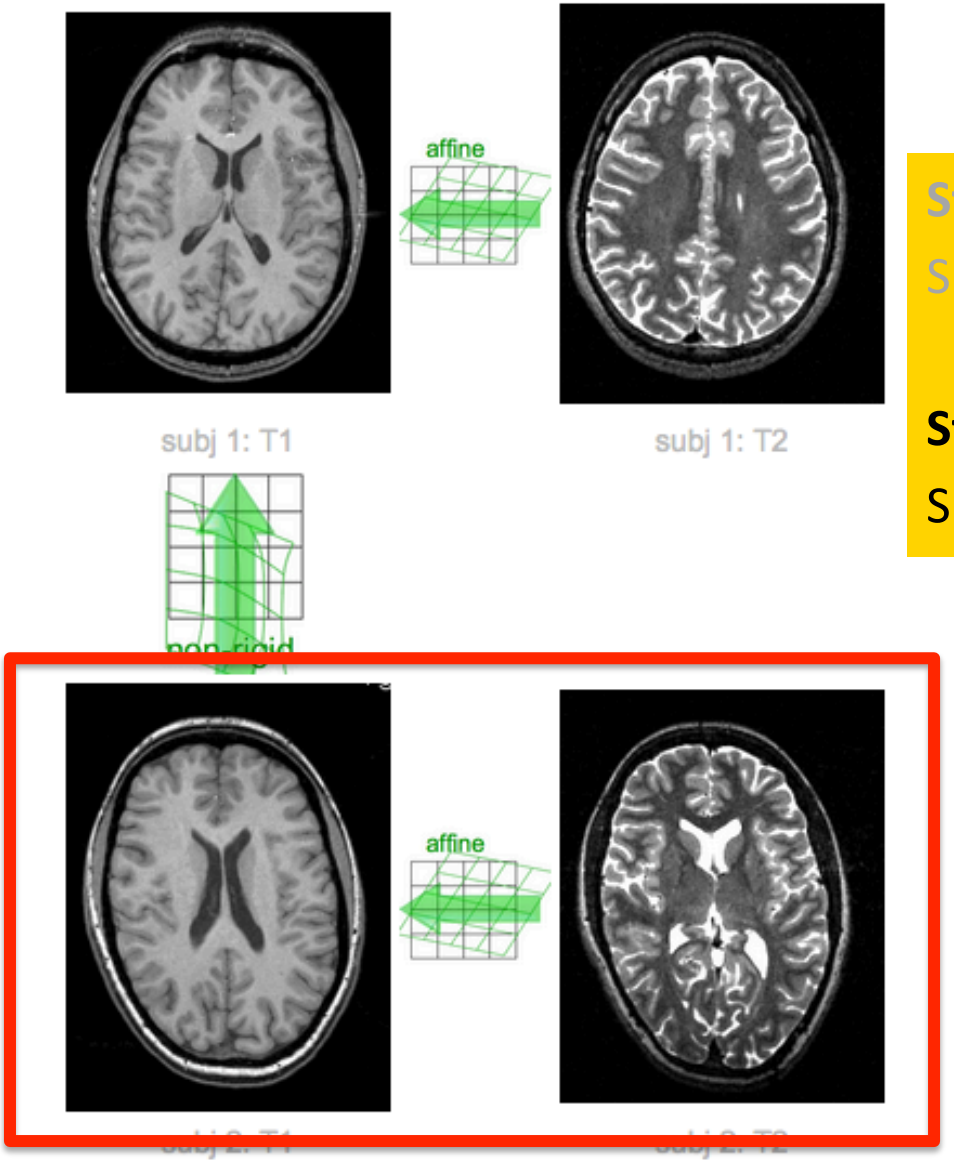


Step 1:

Subject A, T2 to T1 registration

Image courtesy of Dominik Meier, Ph.D.

Registration pipeline



Step 1:

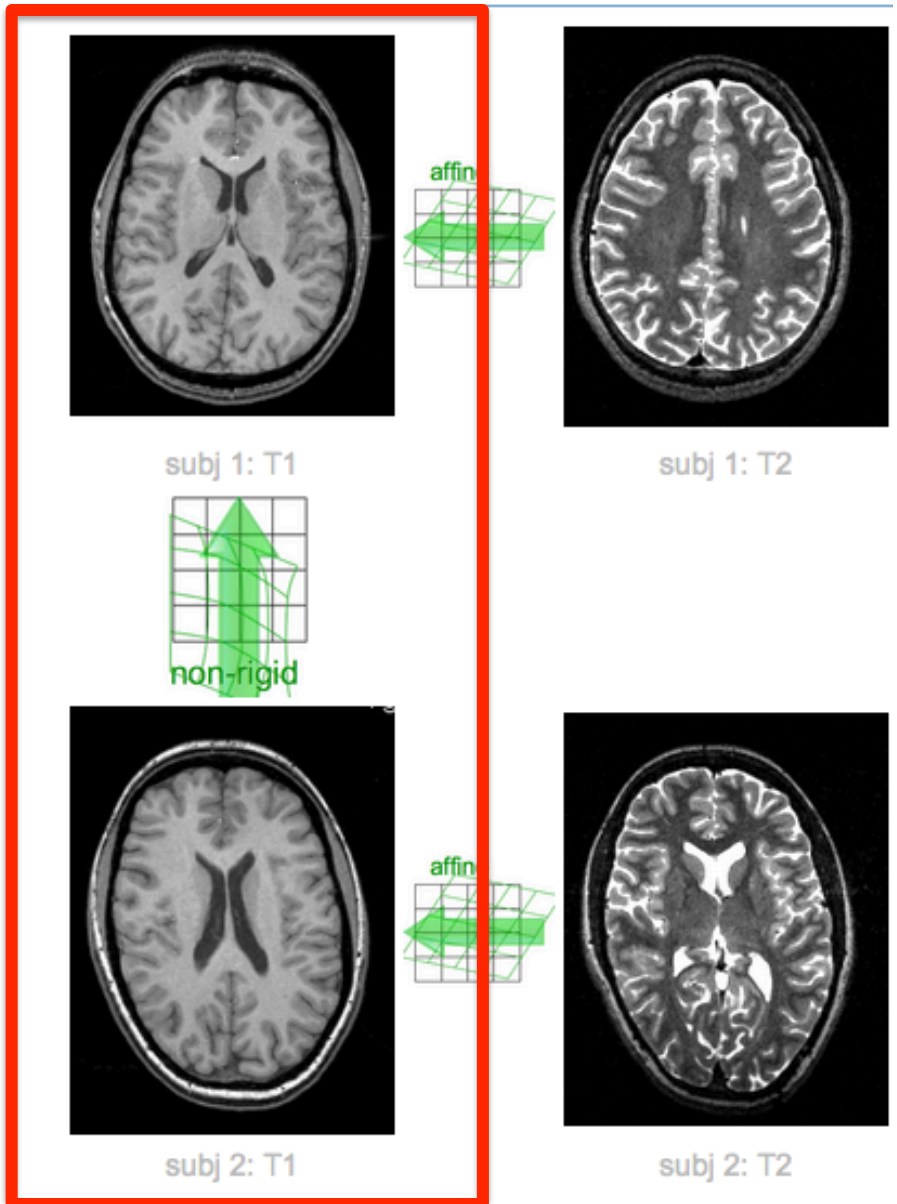
Subject A, T2 to T1 registration

Step 2:

Subject B, T2 to T1 registration

Image courtesy of Dominik Meier, Ph.D.

Registration pipeline



Step 1:

Subject A, T2 to T1 registration

Step 2:

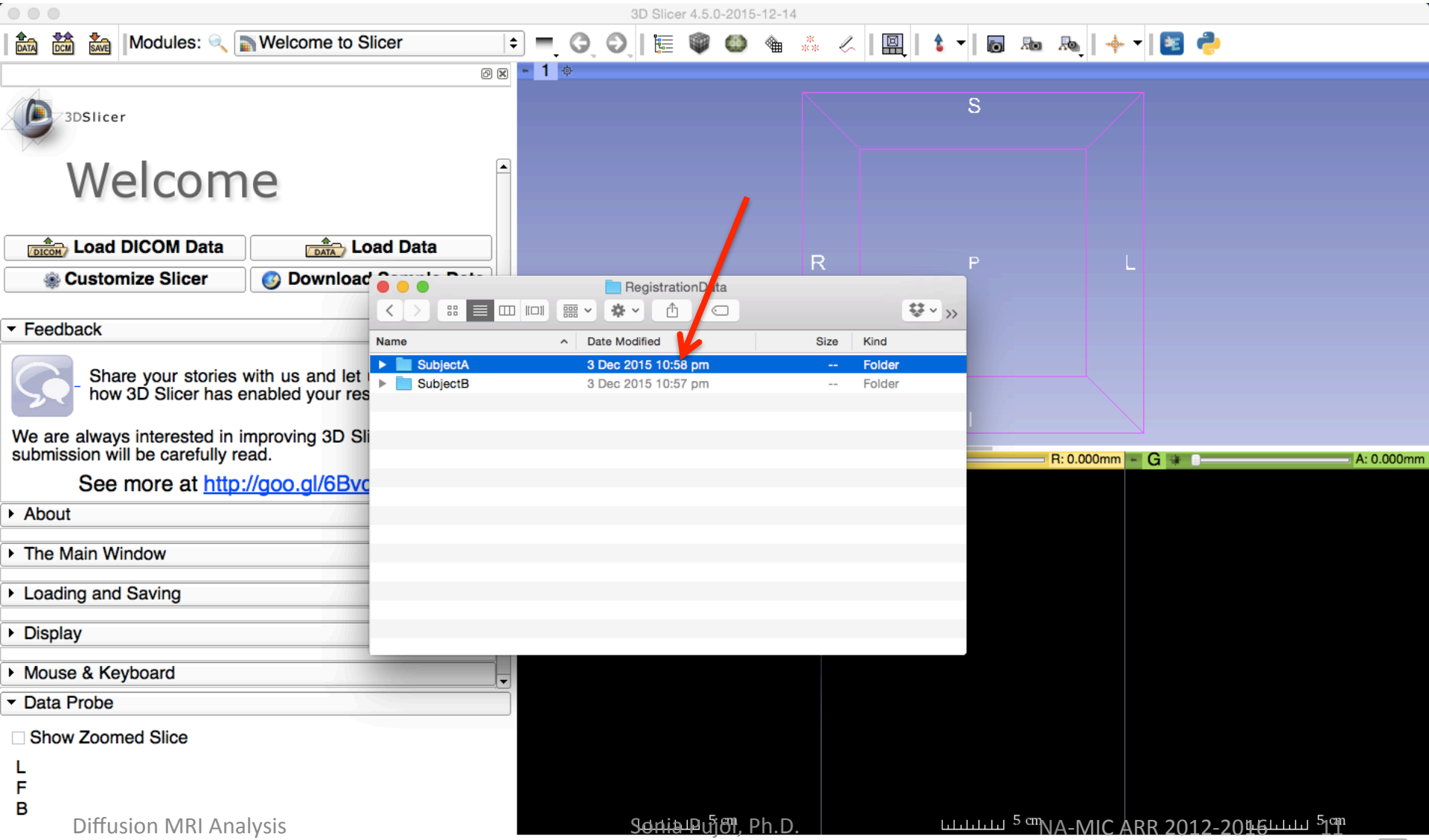
Subject B, T2 to T1 registration

Step 3:

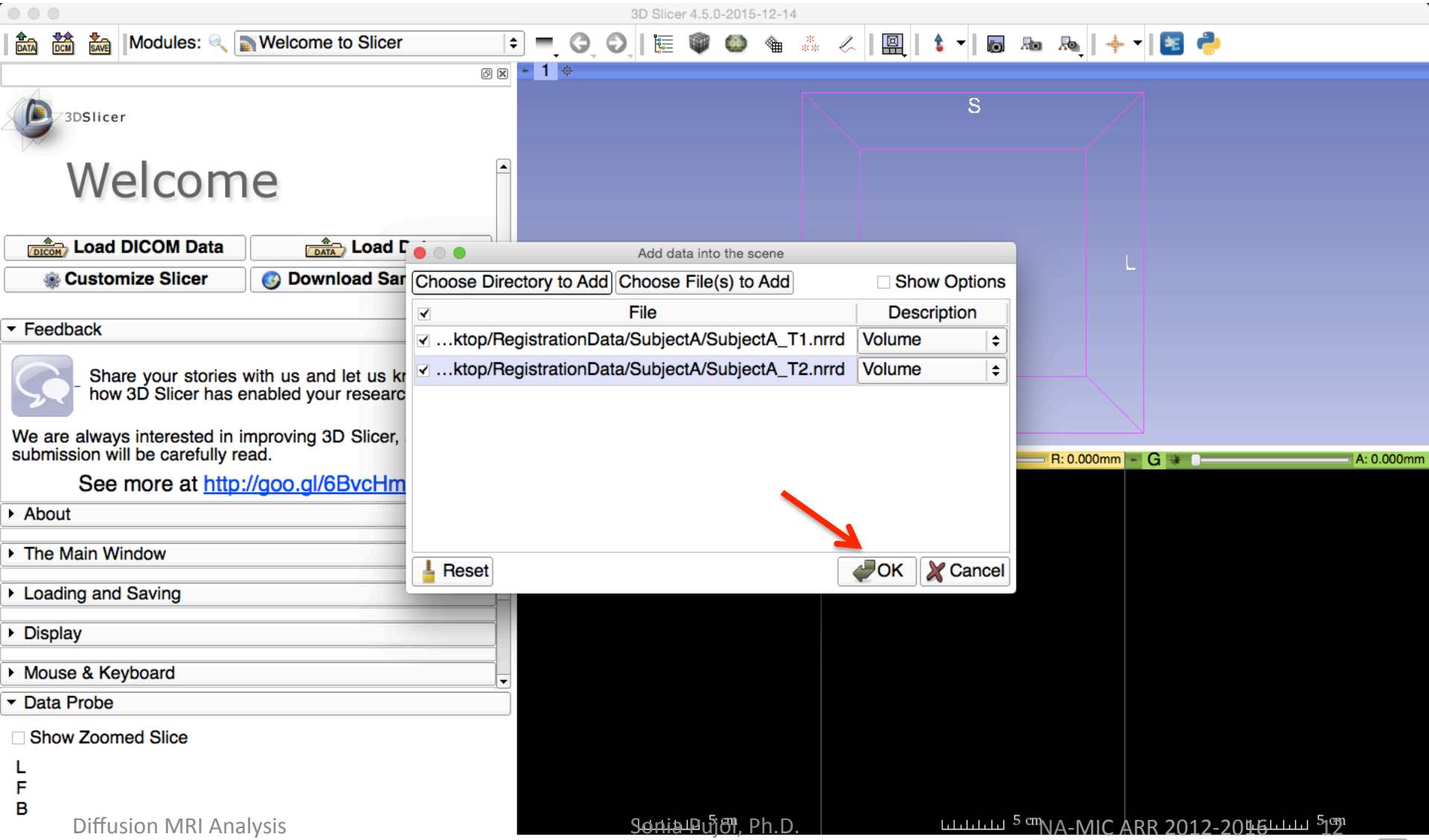
Subject B, T1 to Subject A, T1 registration

Image courtesy of Dominik Meier, Ph.D.

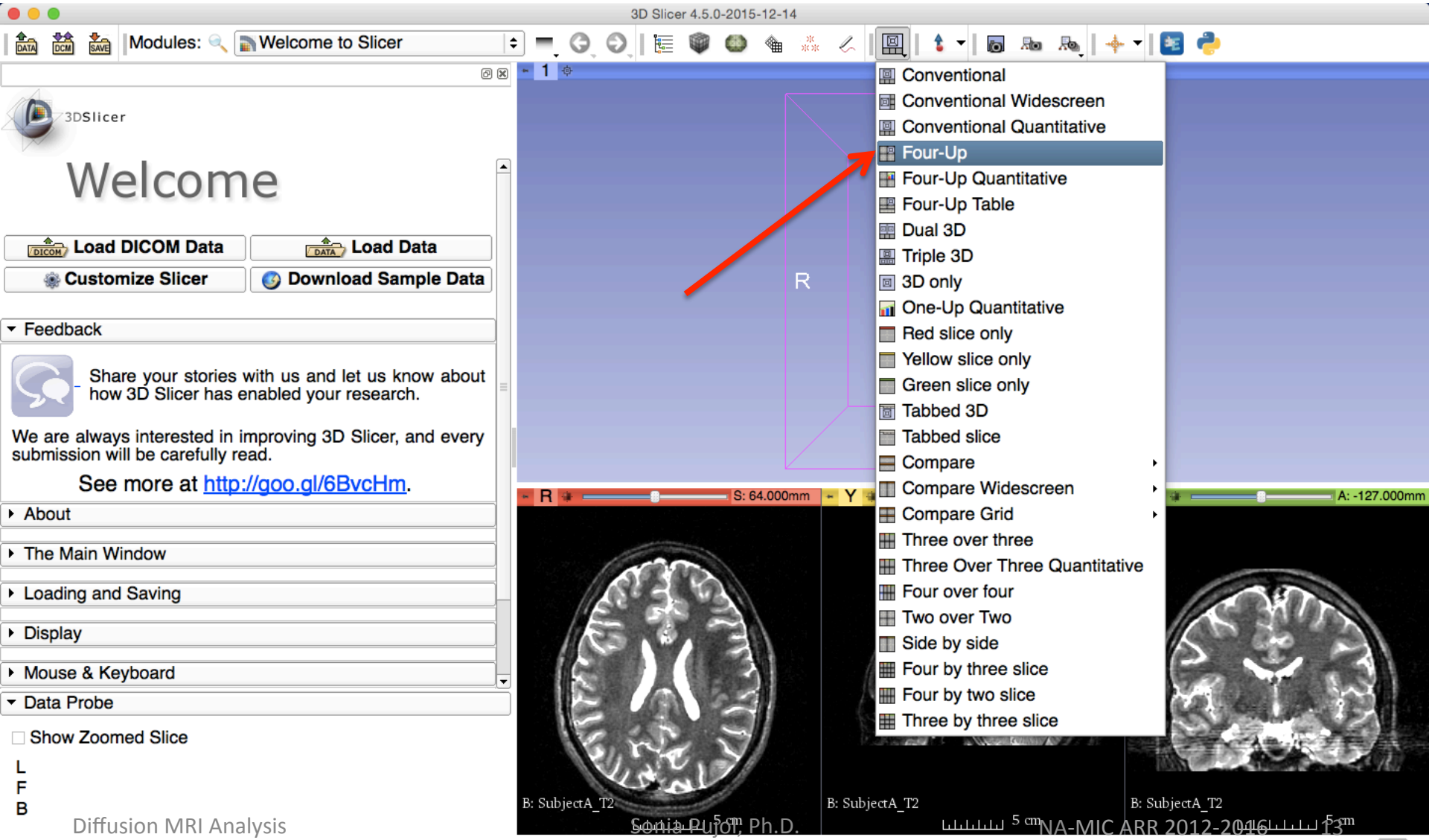
Subject A: Data loading



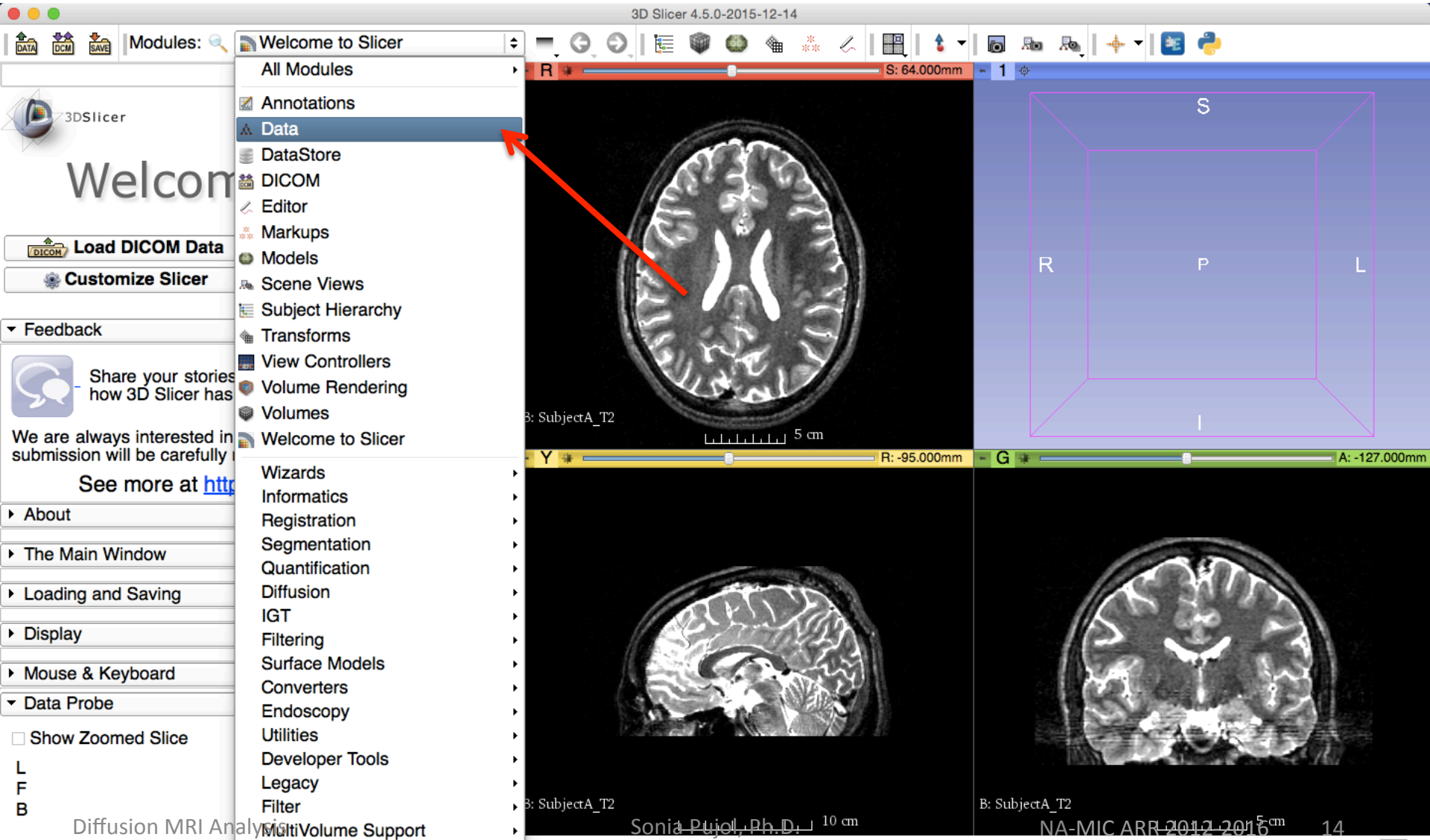
Subject A: Data loading



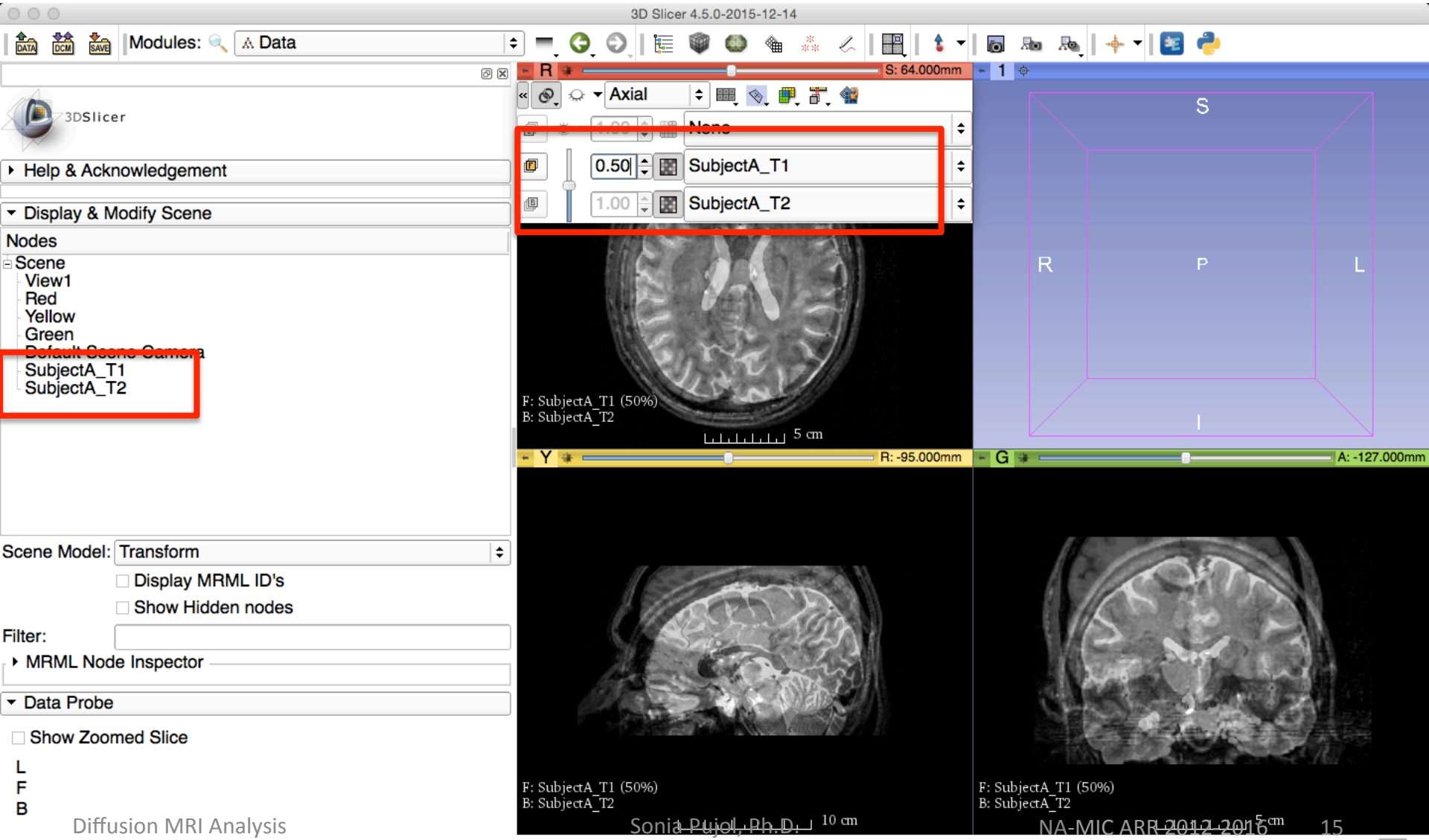
Subject A: Data loading



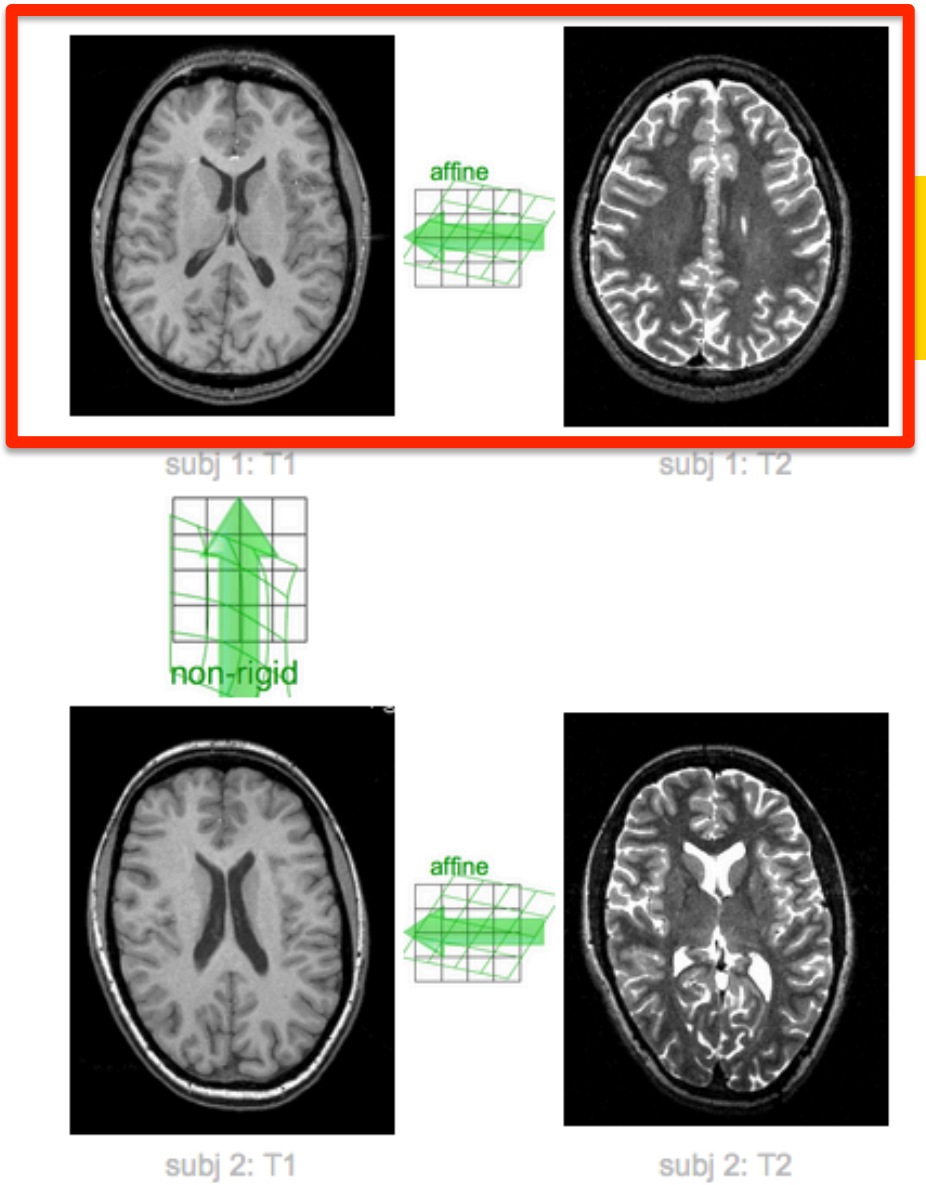
Subject A: Initial mis-registration



Subject A: Initial mis-registration



Registration pipeline

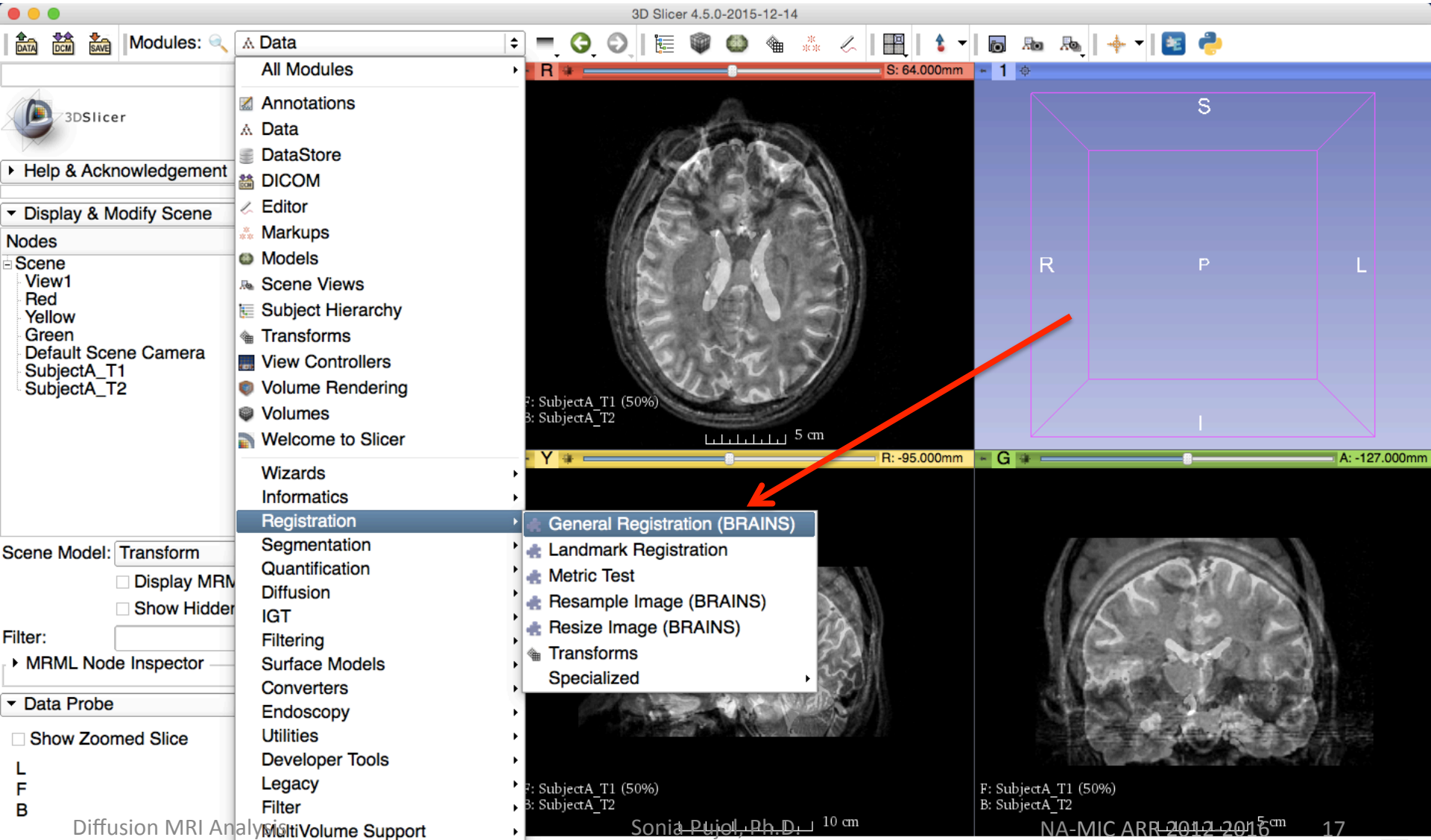


Step 1:

Subject A, T2 to T1 registration

Image courtesy of Dominik Meier, Ph.D.

Subject A: Data registration



Subject A: Data registration

3D Slicer 4.5.0-2015-12-14

Modules: General Registration (BRAINS)

3DSlicer

Help & Acknowledgement

General Registration (BRAINS)

Parameter set: General Registration (BRAINS)

Input Images

Fixed Image Volume: SubjectA_T1

Moving Image Volume: SubjectA_T2

Percentage Of Samples: 0.002

B-Spline Grid Size: 14,10,12

Output Settings (At least one output must be specified)

Slicer Linear Transform: Xf2_SubjectA_T2_to_T1

Slicer BSpline Transform: None

Output Image Volume: None

Transform Initialization Settings

Initialization transform: None

Initialize Transform Mode: Off

Status: Idle

Restore Defaults | AutoRun | Cancel | Apply

Data Probe

Yellow RAS: (-95.0, -124.5, 112.3) Sagittal Sp: 1.0

L None

F SubjectA_T1 (95, 124, 112) 87

B SubjectA_T2 (95, 124, 112) 302

R S: 64.000mm

F: SubjectA_T1 (50%)
B: SubjectA_T2
5 cm

1

S
R P L
I

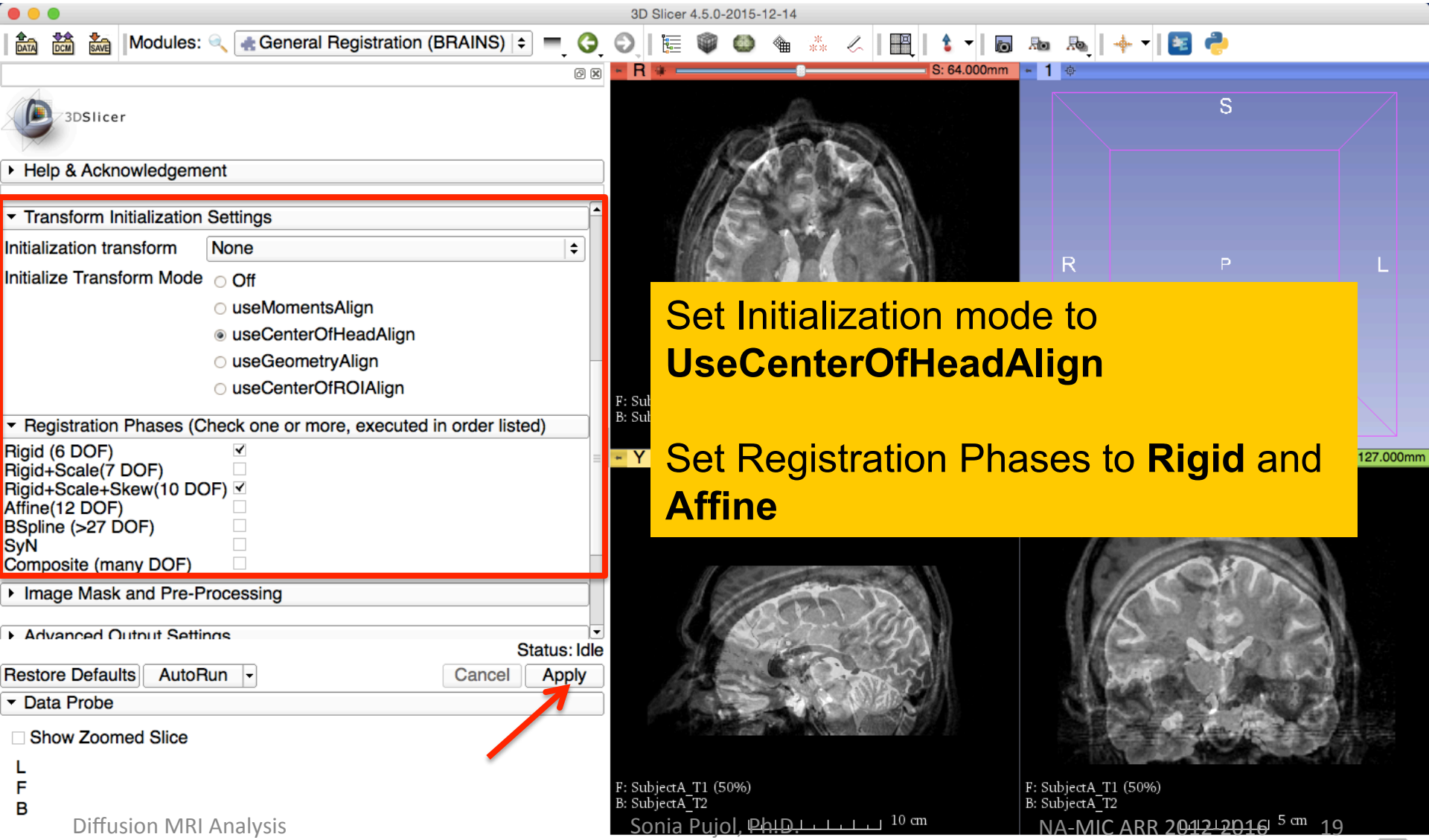
Y R: -95.000mm

F: SubjectA_T1 (50%)
B: SubjectA_T2
10 cm

G A: -127.000mm

F: SubjectA_T1 (50%)
B: SubjectA_T2
5 cm

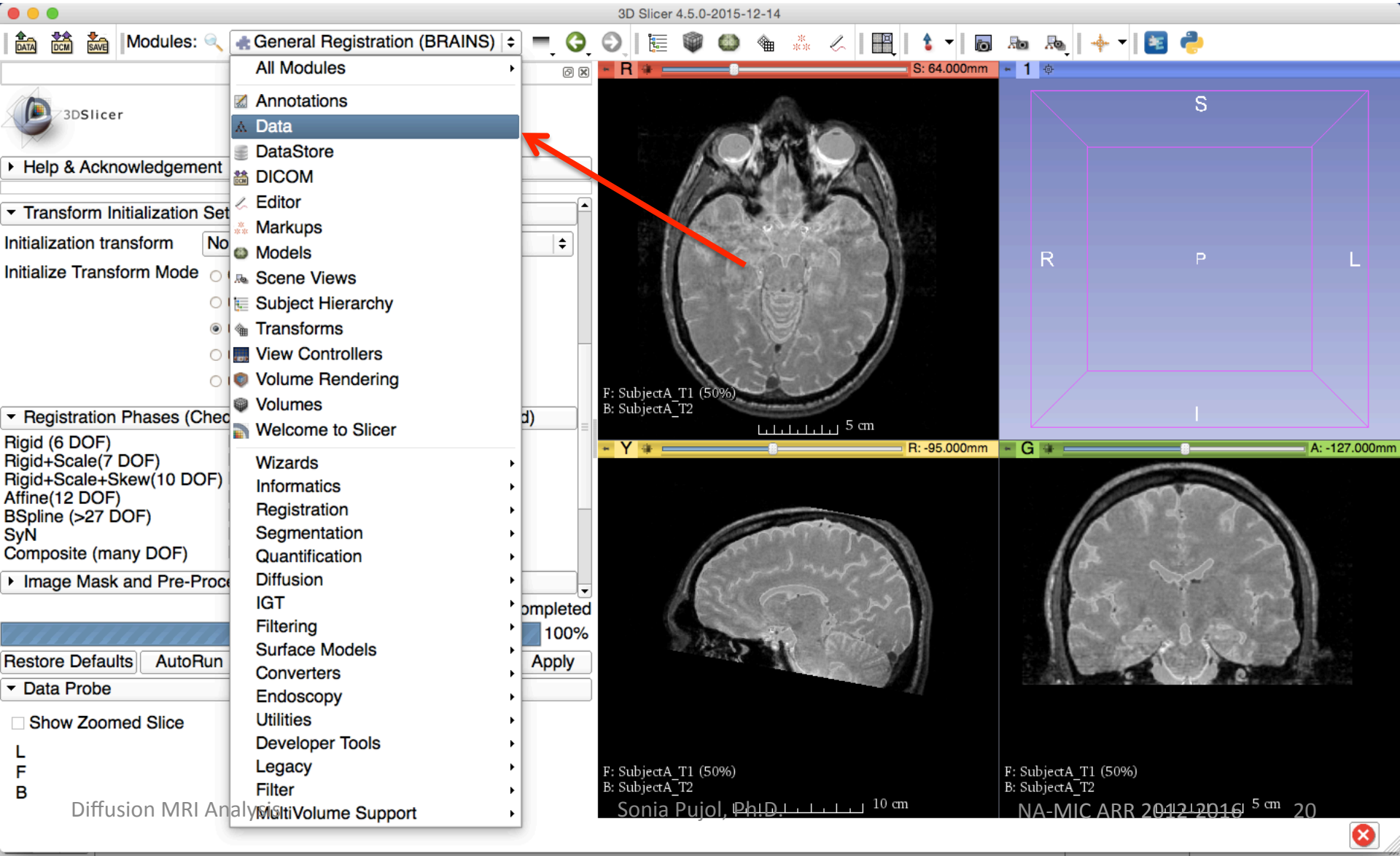
Subject A: Data registration



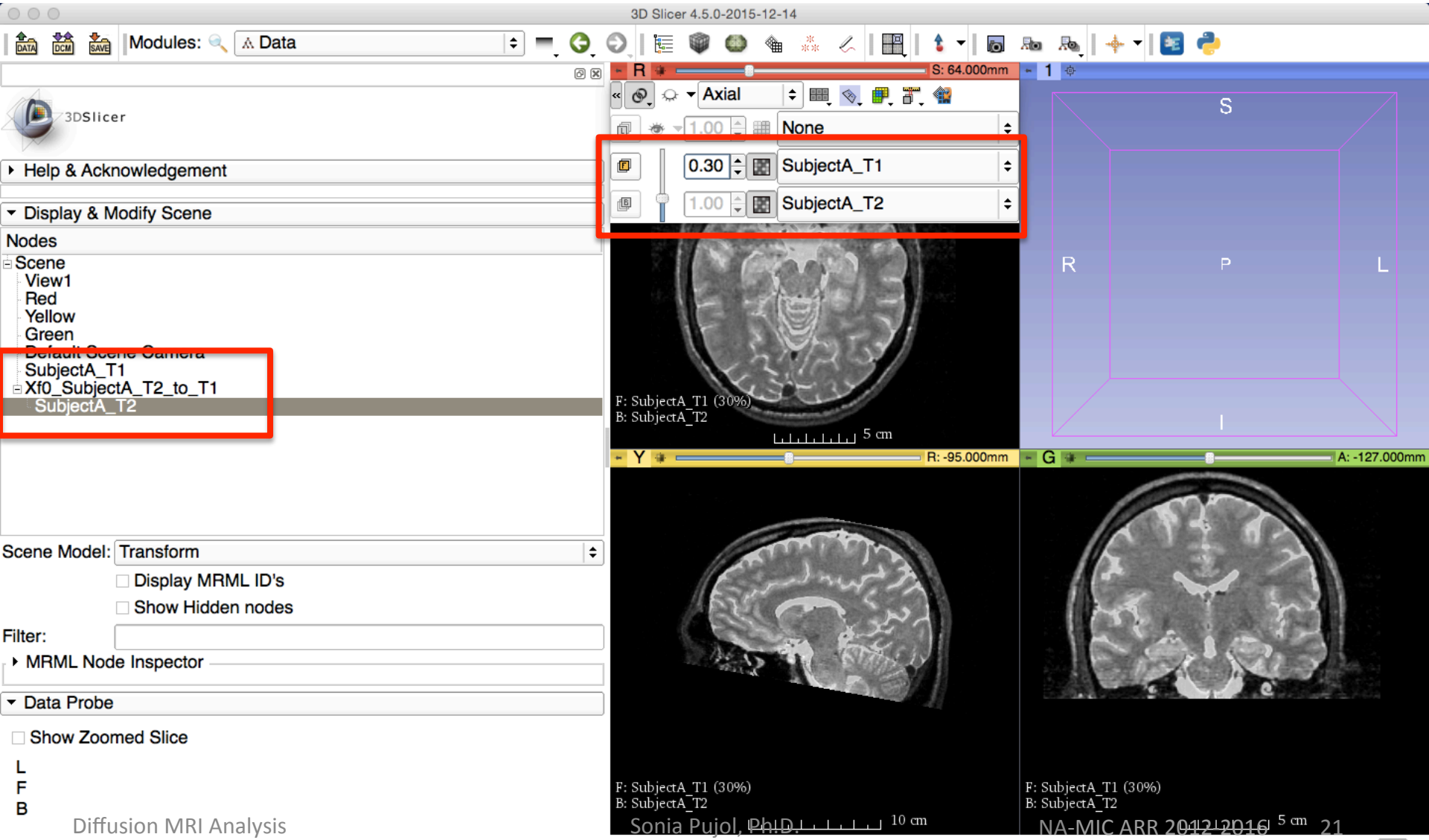
Set Initialization mode to **UseCenterOfHeadAlign**

Set Registration Phases to **Rigid** and **Affine**

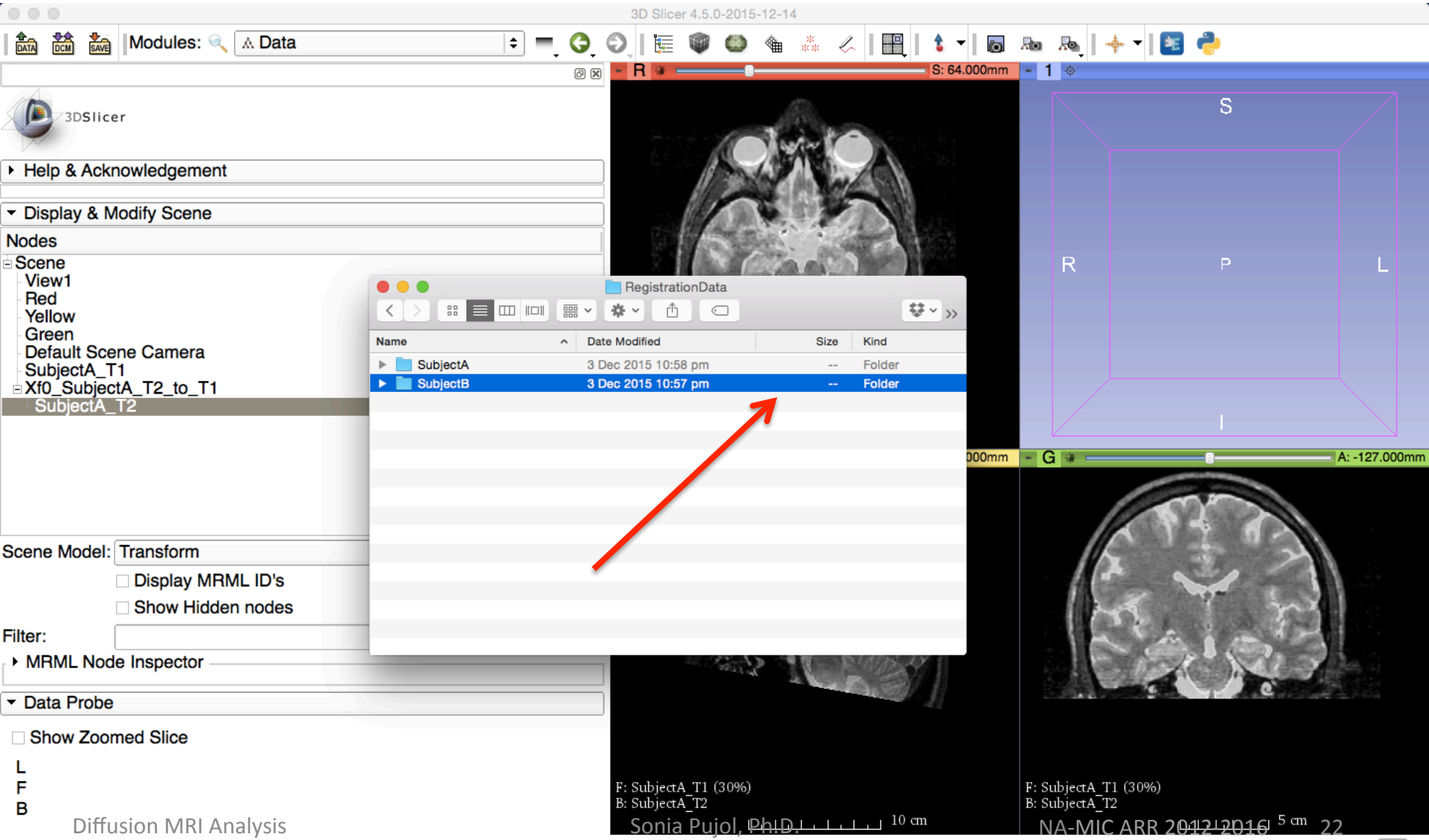
Subject A: Data registration



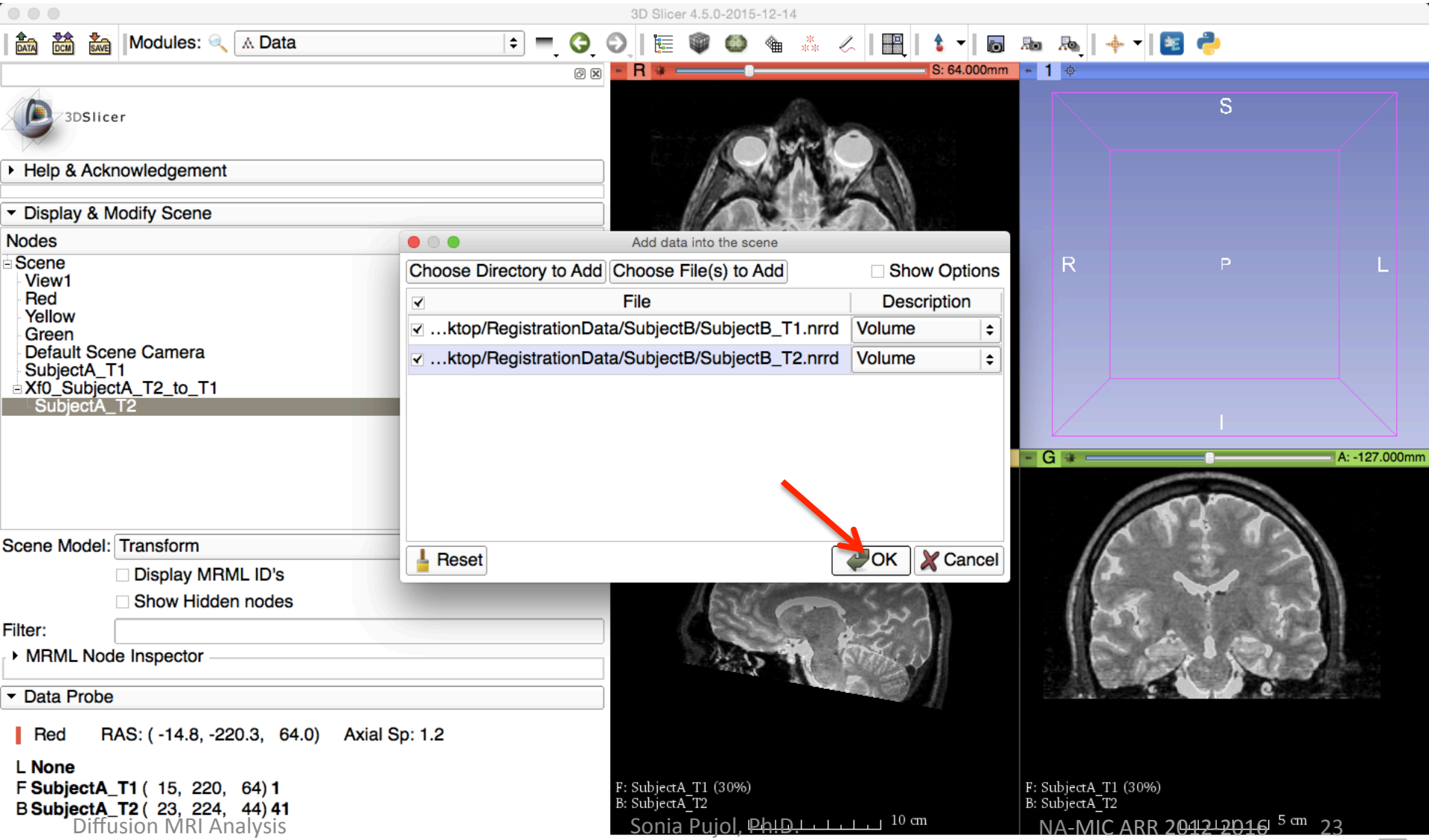
Rigid Affine Transformation



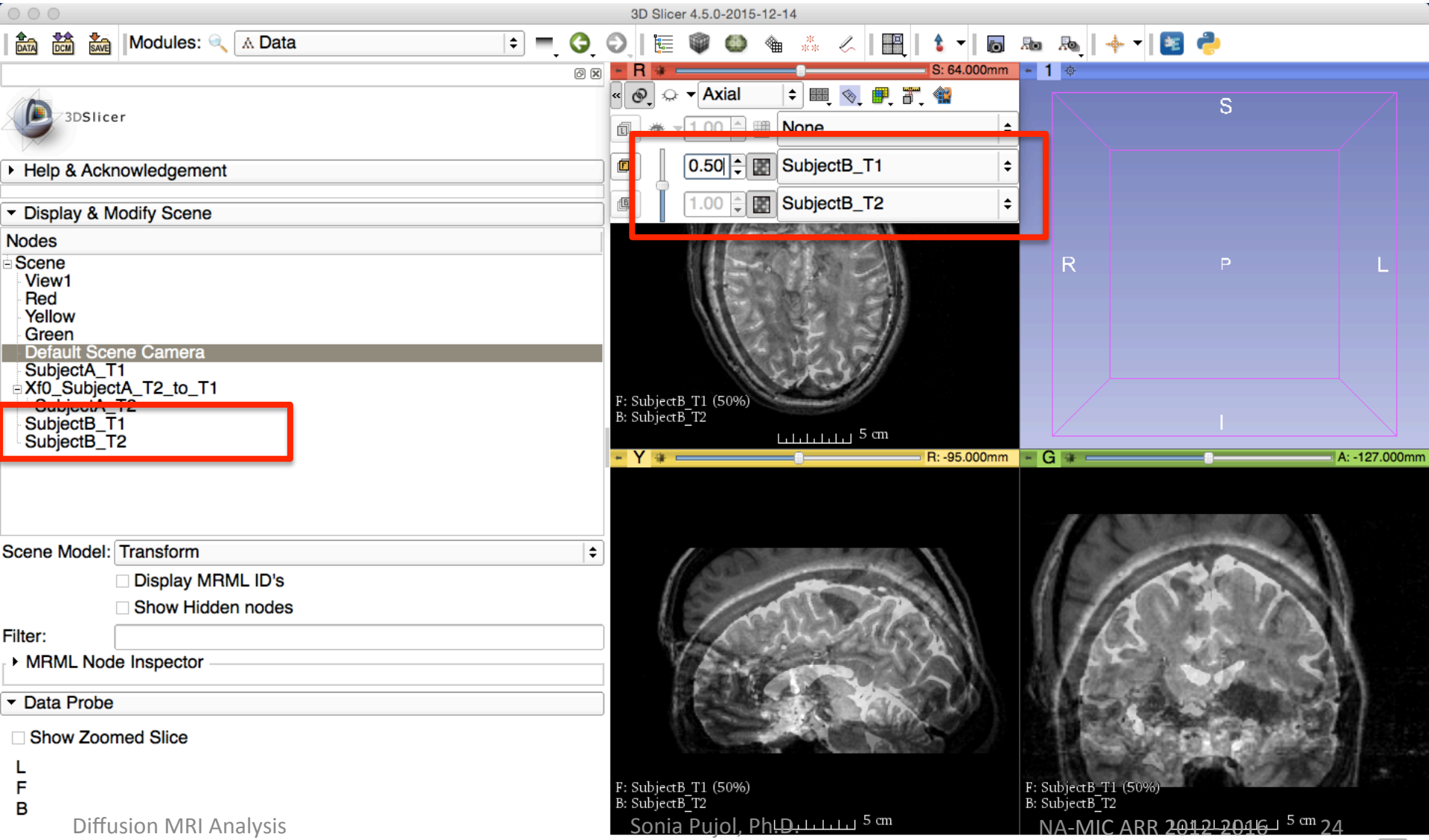
Subject B: Data Loading



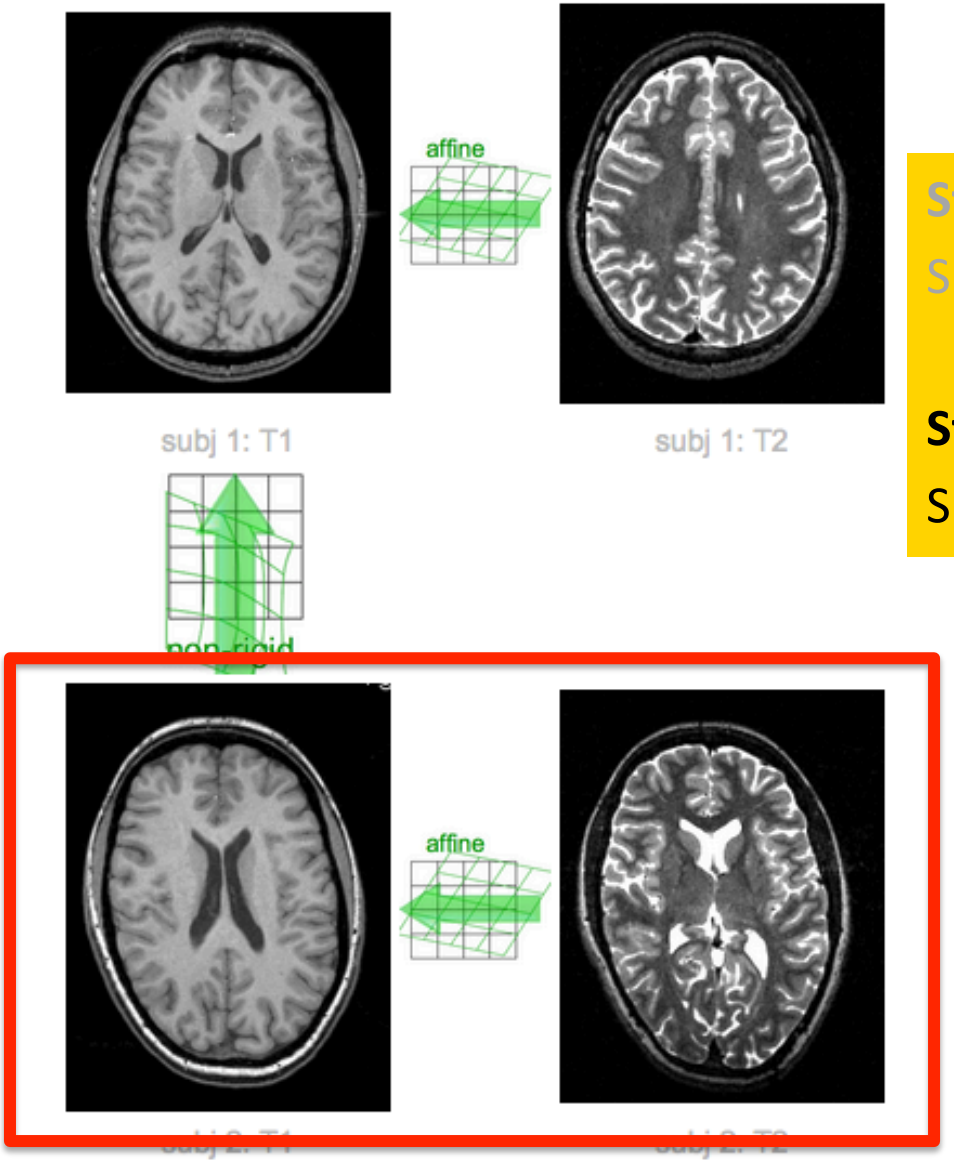
Subject B: Data Loading



Subject B: Initial mis-registration



Registration pipeline



Step 1:

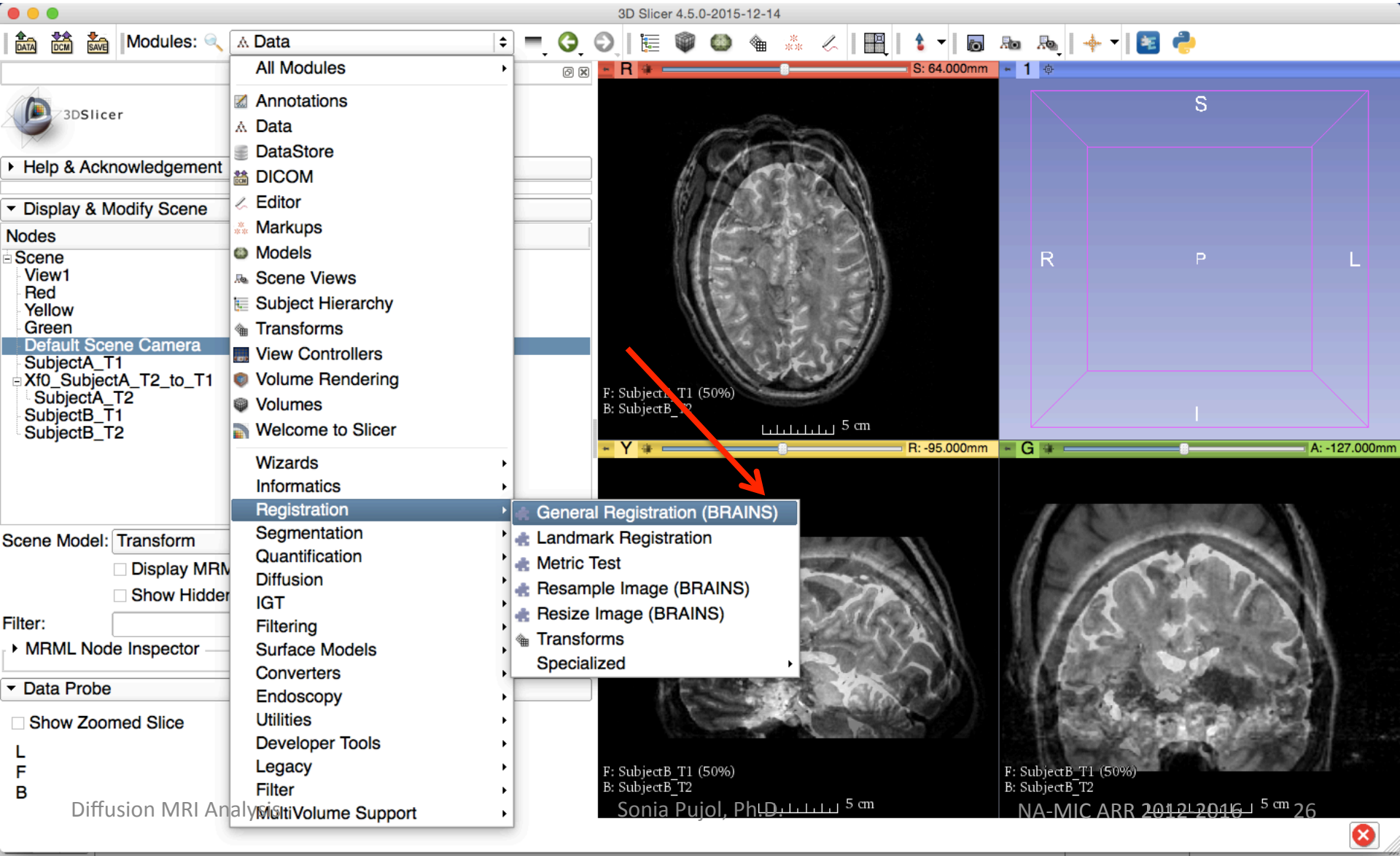
Subject A, T2 to T1 registration

Step 2:

Subject B, T2 to T1 registration

Image courtesy of Dominik Meier, Ph.D.

Data Registration



Subject B: Data Registration

3D Slicer 4.5.0-2015-12-14

Modules: General Registration (BRAINS)

3DSlicer

Help & Acknowledgement

General Registration (BRAINS)

Parameter set: General Registration (BRAINS)

Input Images

Fixed Image Volume: SubjectB_T1

Moving Image Volume: SubjectB_T2

Percentage Of Samples: 0.002

B-Spline Grid Size: 14,10,12

Output Settings (At least one output must be specified)

Slicer Linear Transform: Xf1_SubjectB_T2_to_T1

Slicer BSpline Transform: None

Output Image Volume: None

Transform Initialization Settings

Initialization transform: None

Initialize Transform Mode: Off

Status: Completed

100%

Restore Defaults | AutoRun | Cancel | Apply

Data Probe

Show Zoomed Slice

L
F
B

R S: 64.000mm

F: SubjectB_T1 (50%)
B: SubjectB_T2

5 cm

1

S
R P L
I

Y R: -95.000mm

G A: -127.000mm

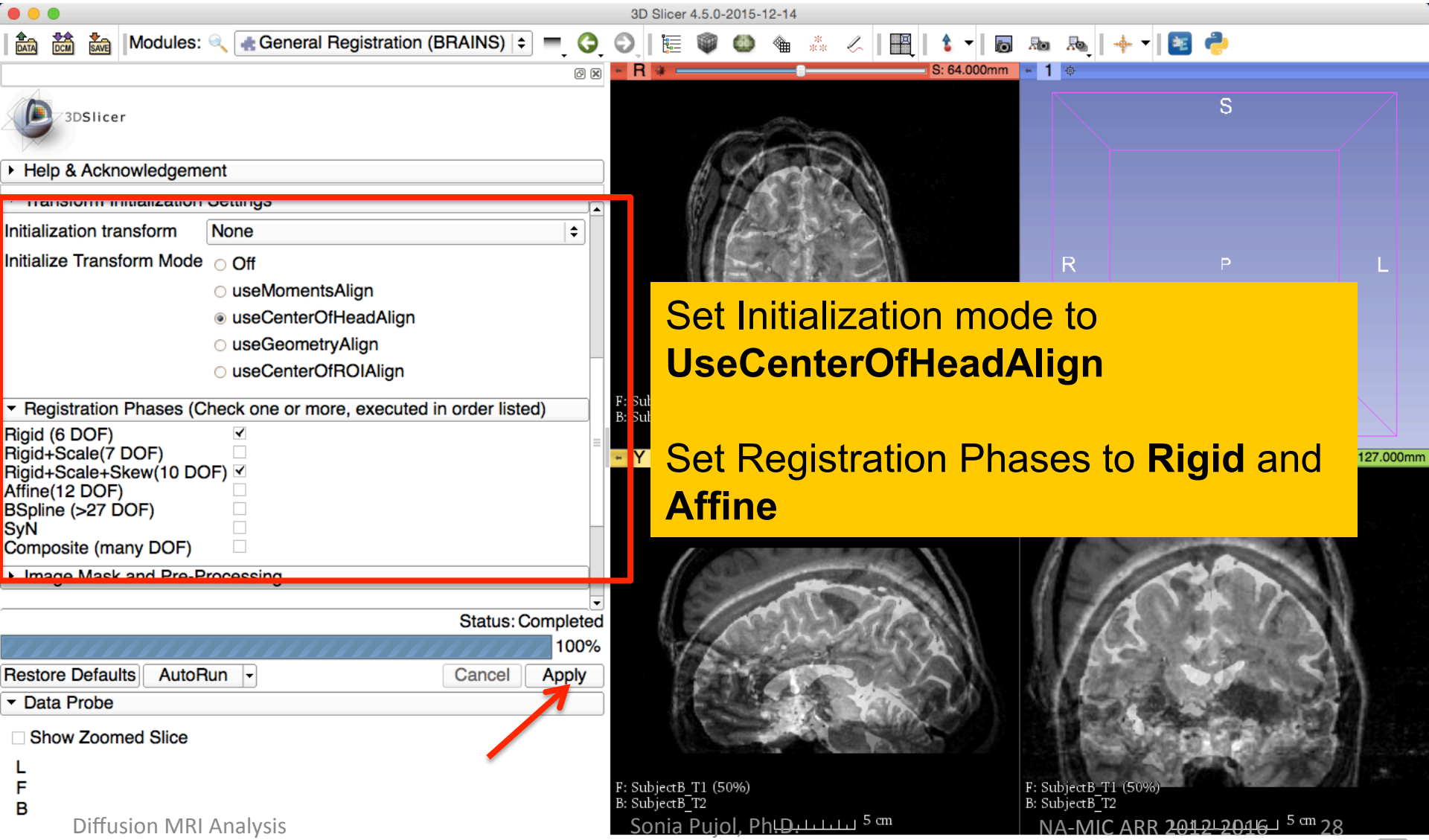
F: SubjectB_T1 (50%)
B: SubjectB_T2

5 cm

F: SubjectB_T1 (50%)
B: SubjectB_T2

5 cm

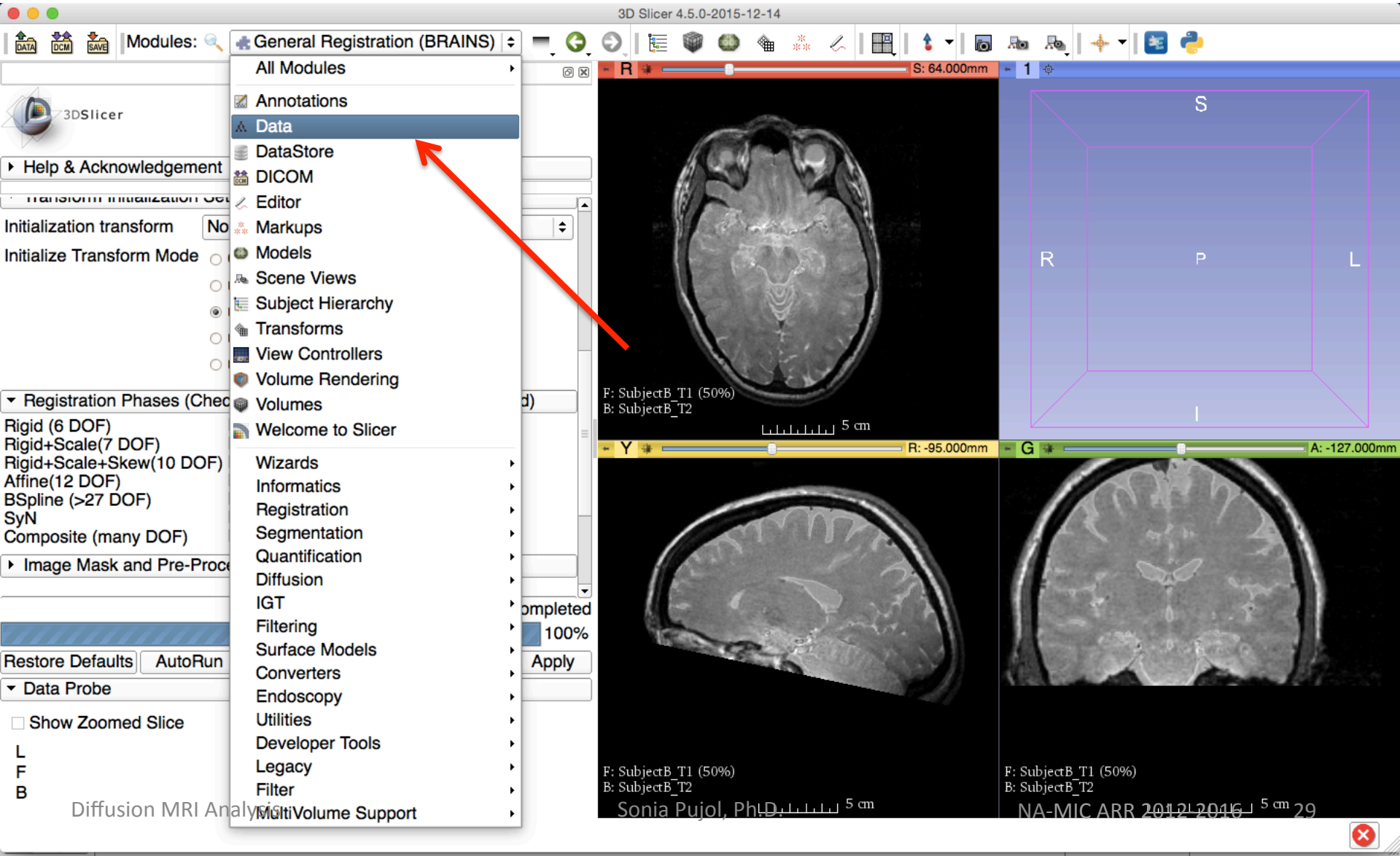
Subject B: Data Registration



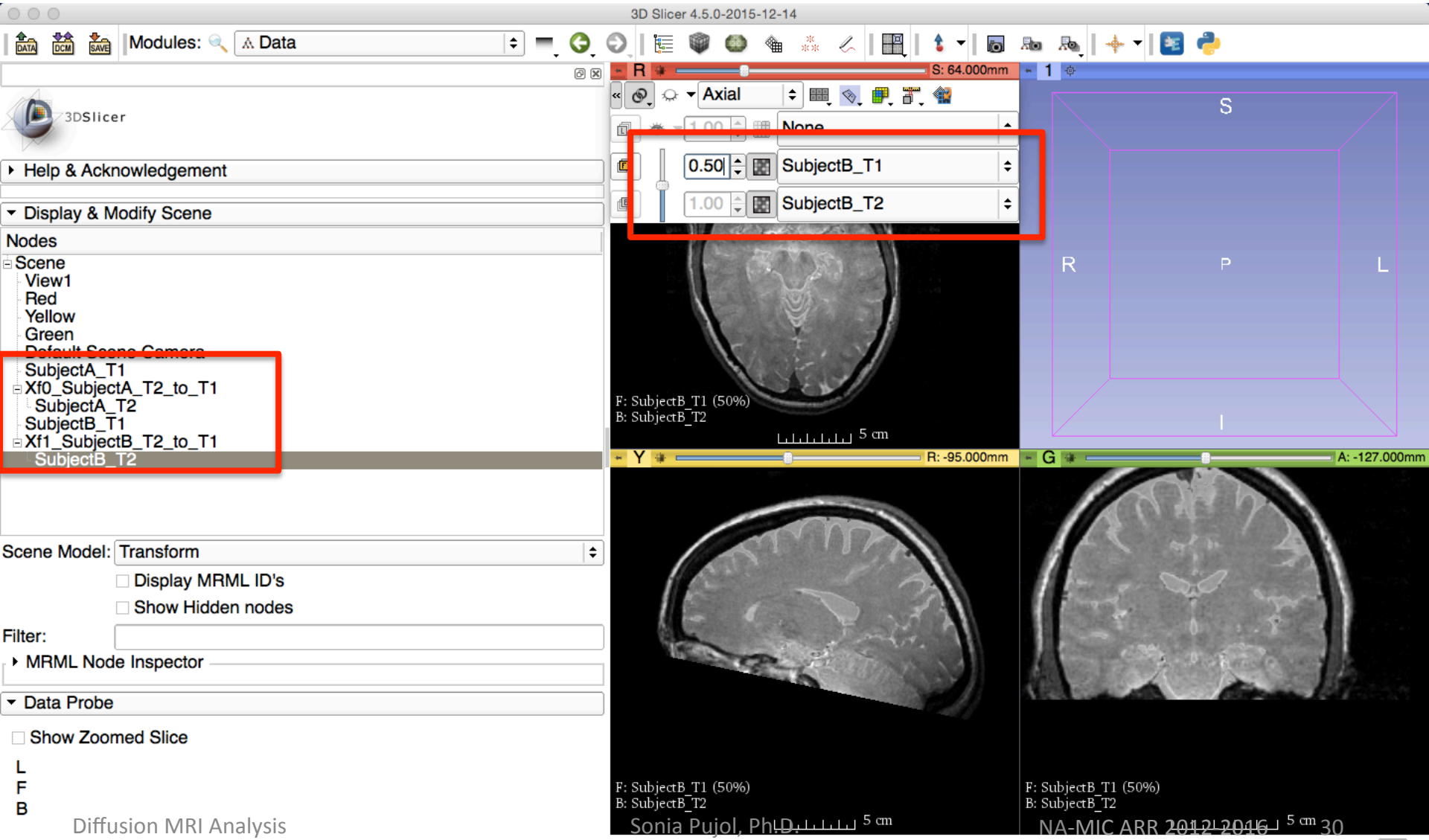
Set Initialization mode to **UseCenterOfHeadAlign**

Set Registration Phases to **Rigid** and **Affine**

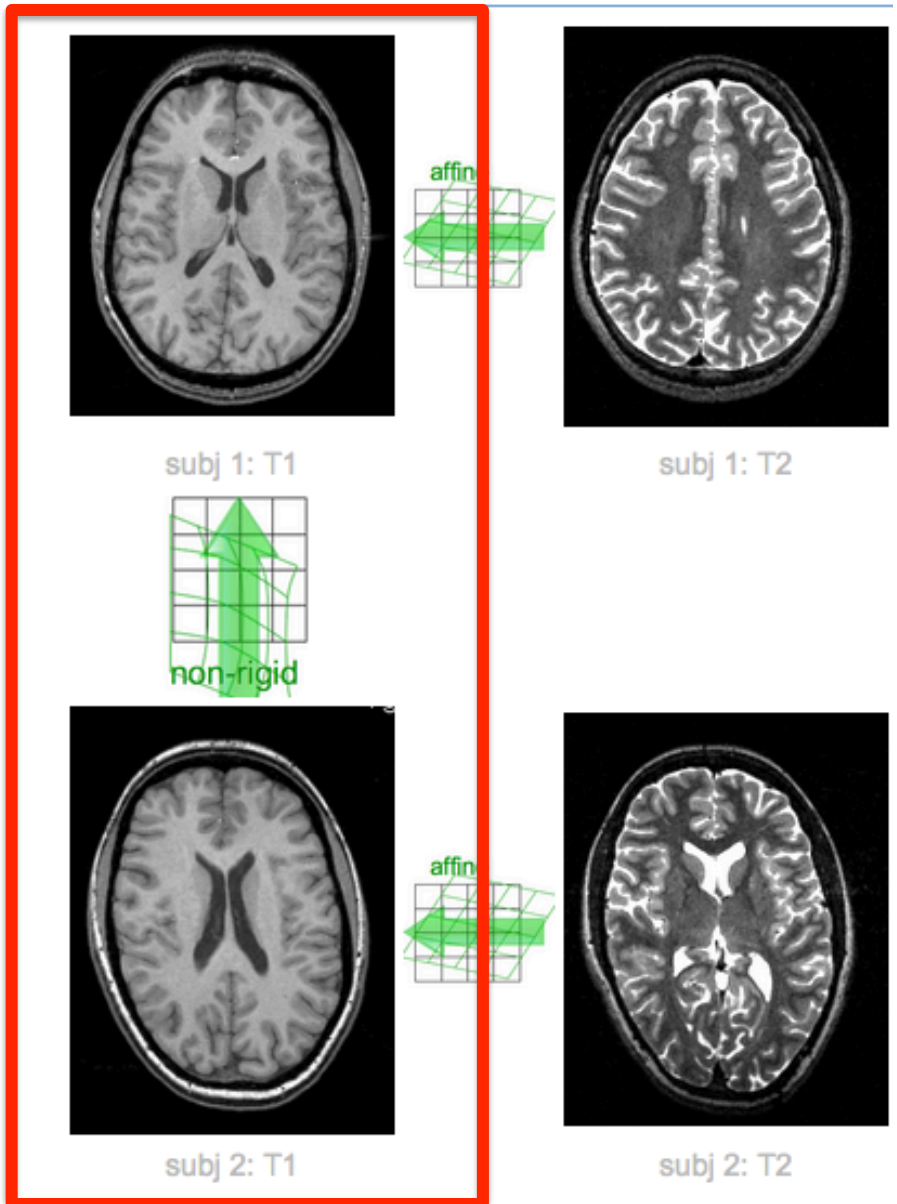
Subject B: Data Registration



Subject B: Data Registration



Registration pipeline



Step 1:

Subject A, T2 to T1 registration

Step 2:

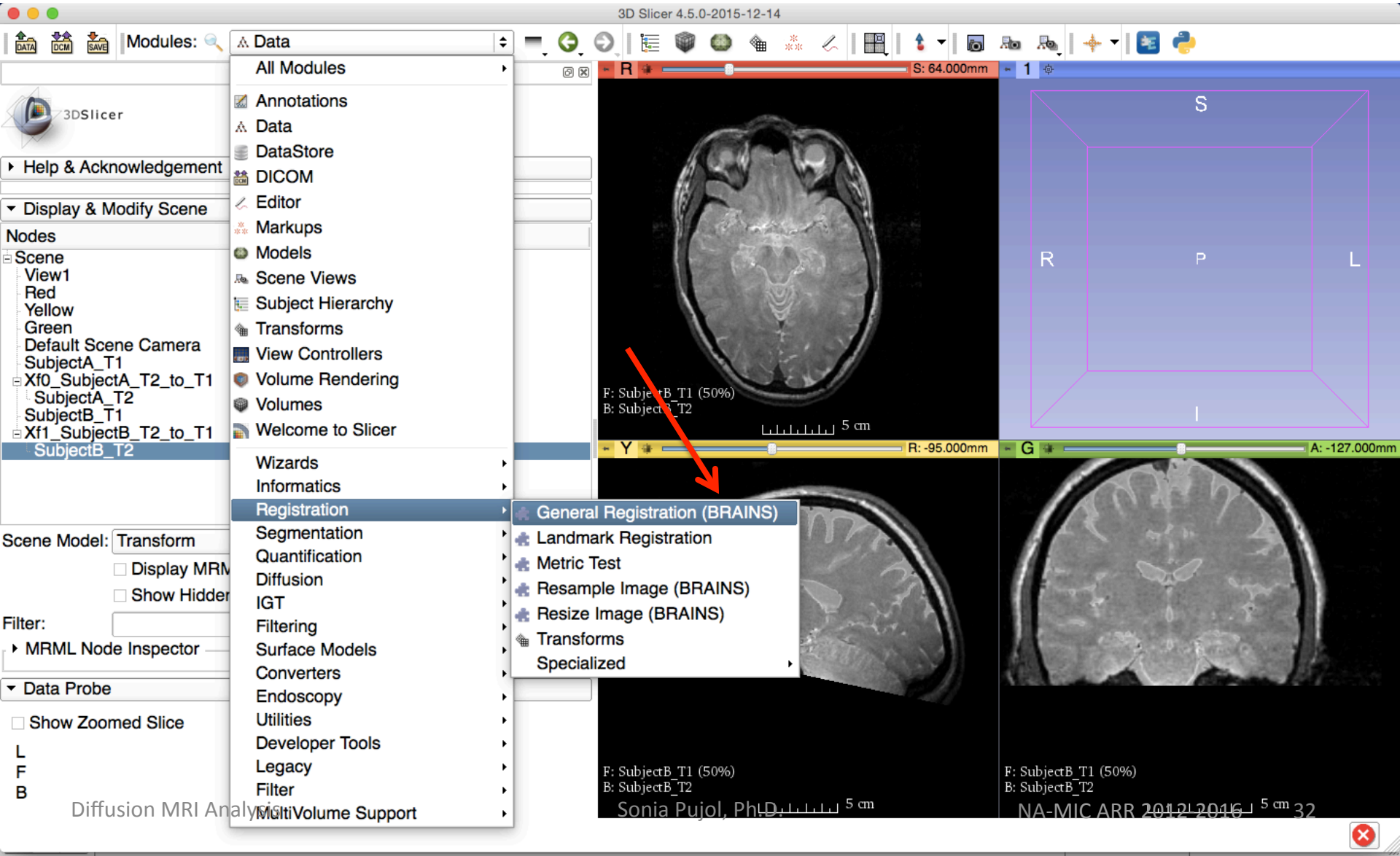
Subject B, T2 to T1 registration

Step 3:

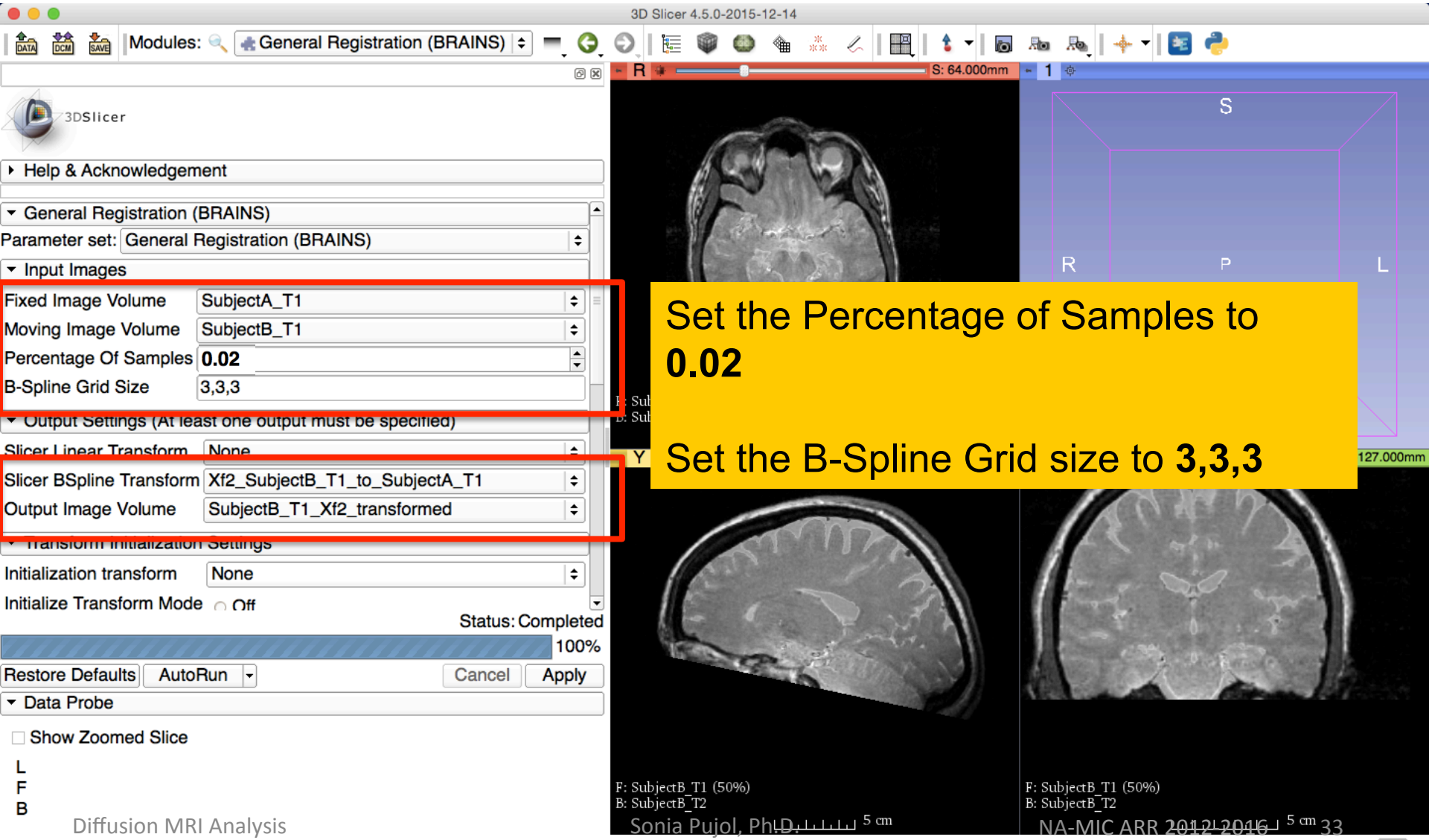
Subject B, T1 to Subject A, T1 registration

Image courtesy of Dominik Meier, Ph.D.

Co-registration of Subject B to Subject A



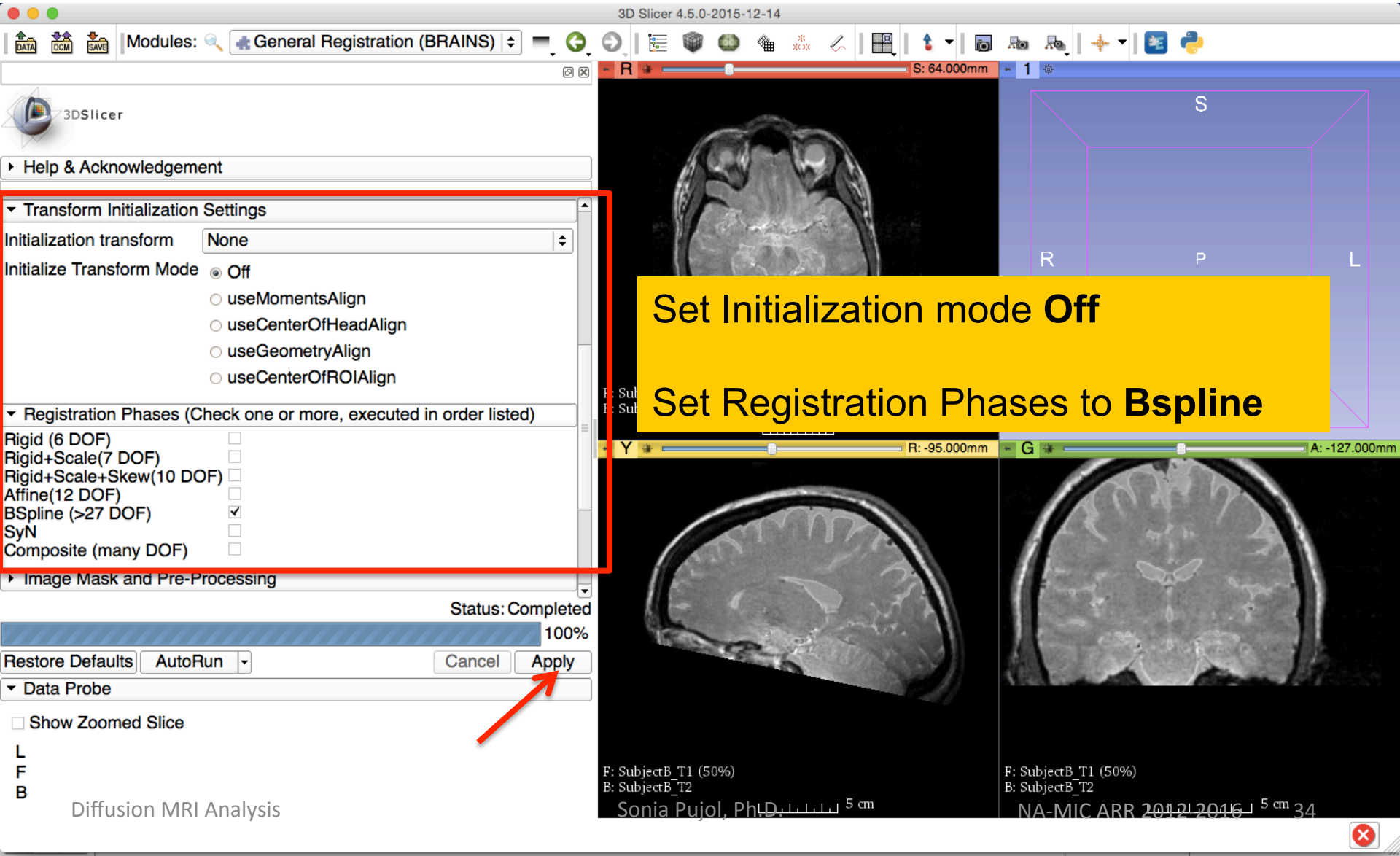
Non rigid registration of Subject B to Subject A



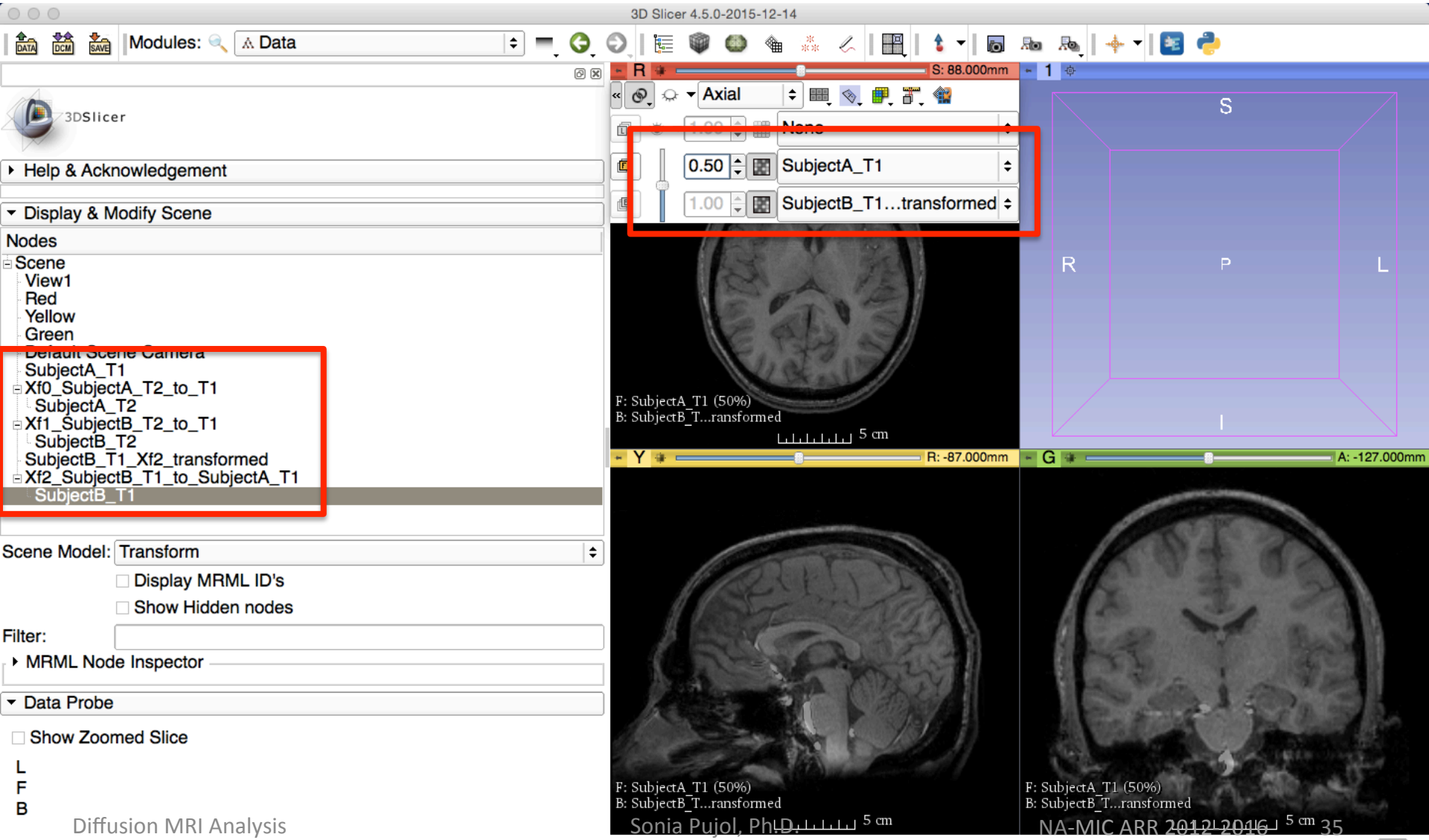
Set the Percentage of Samples to **0.02**

Set the B-Spline Grid size to **3,3,3**

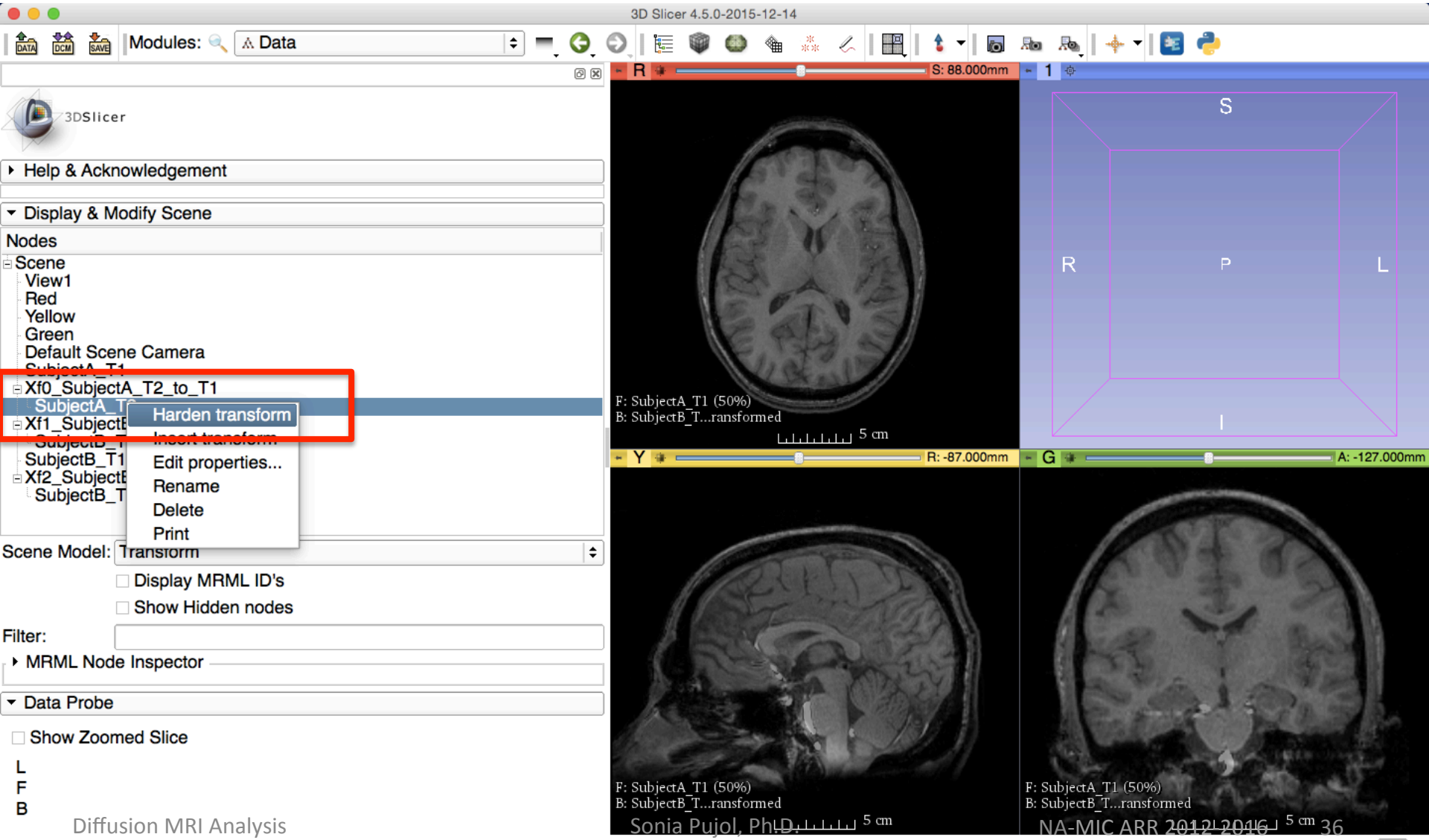
Non rigid registration of Subject B to Subject A



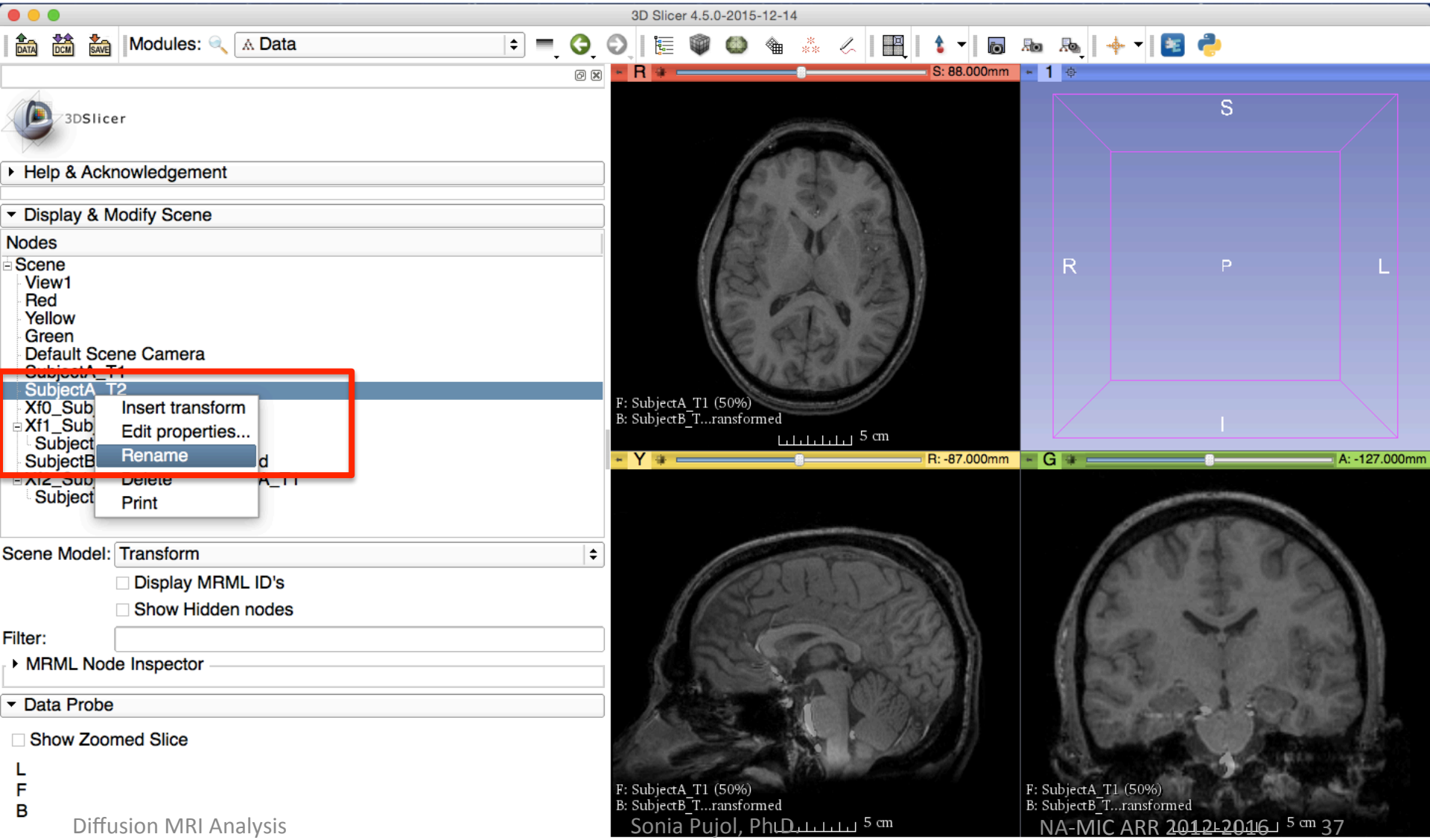
Co-registration of Subject B to Subject A



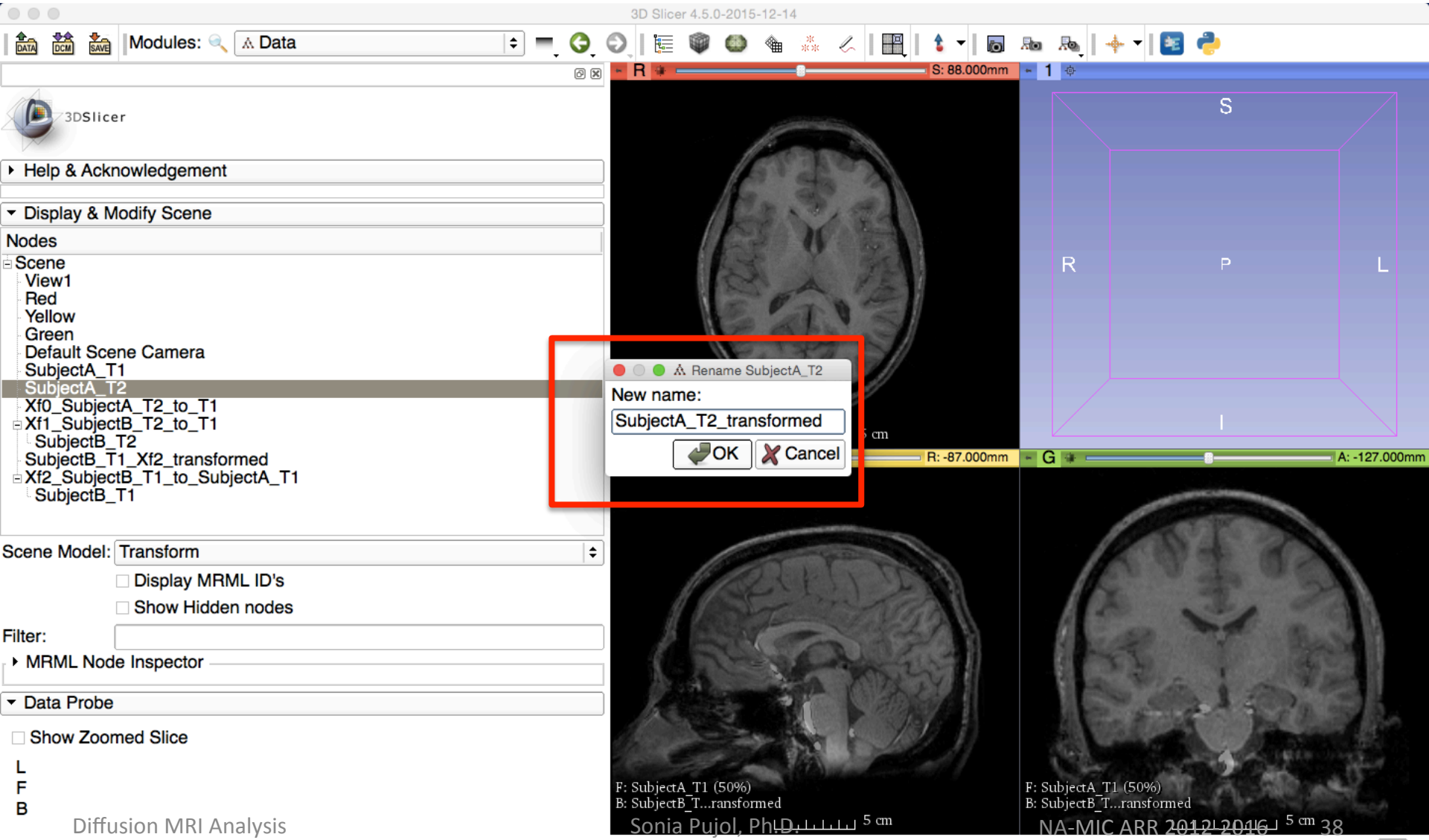
Harden Transform Xf0 (Subject A: T2 to T1)



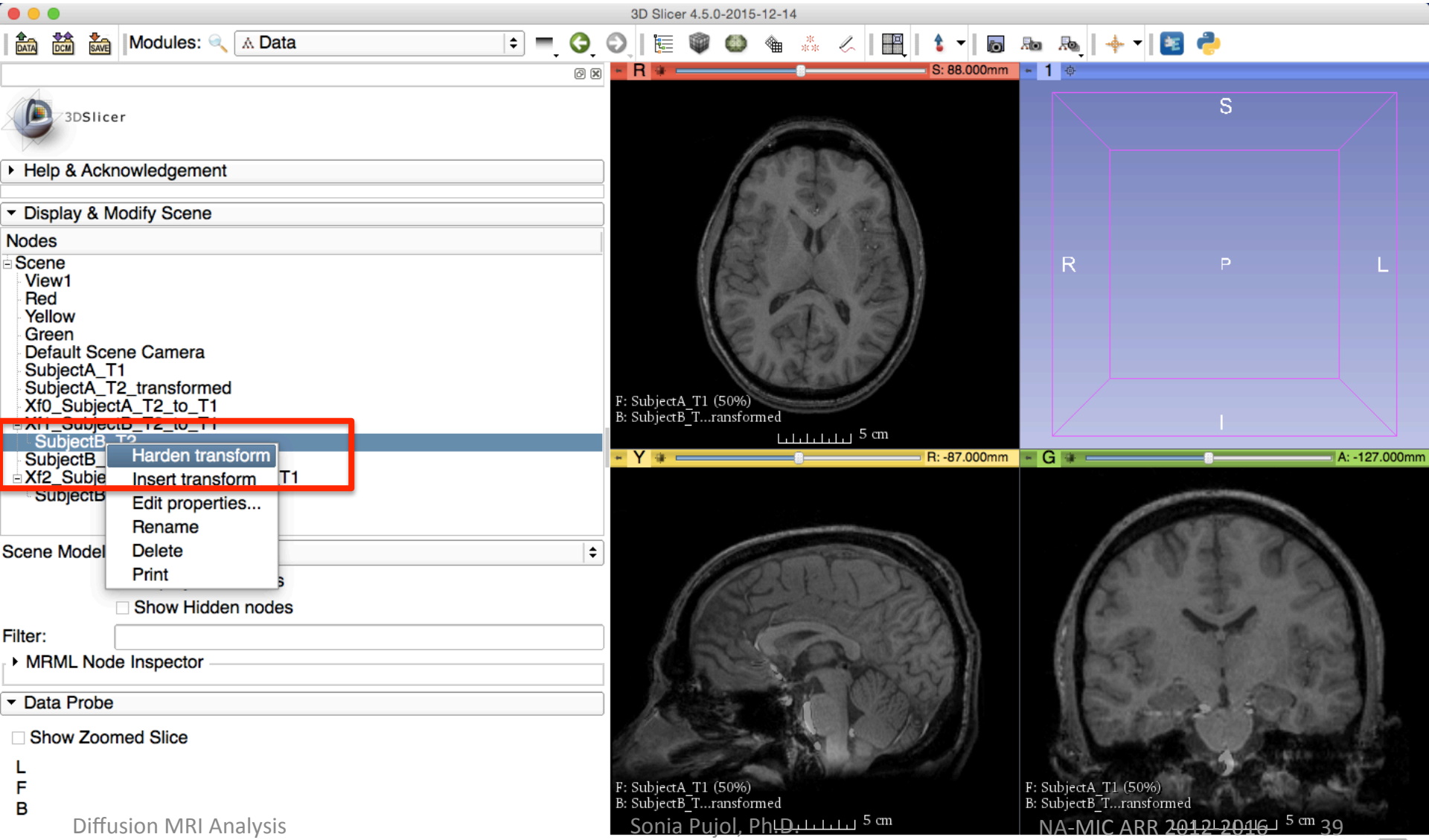
Rename Transformed Volume



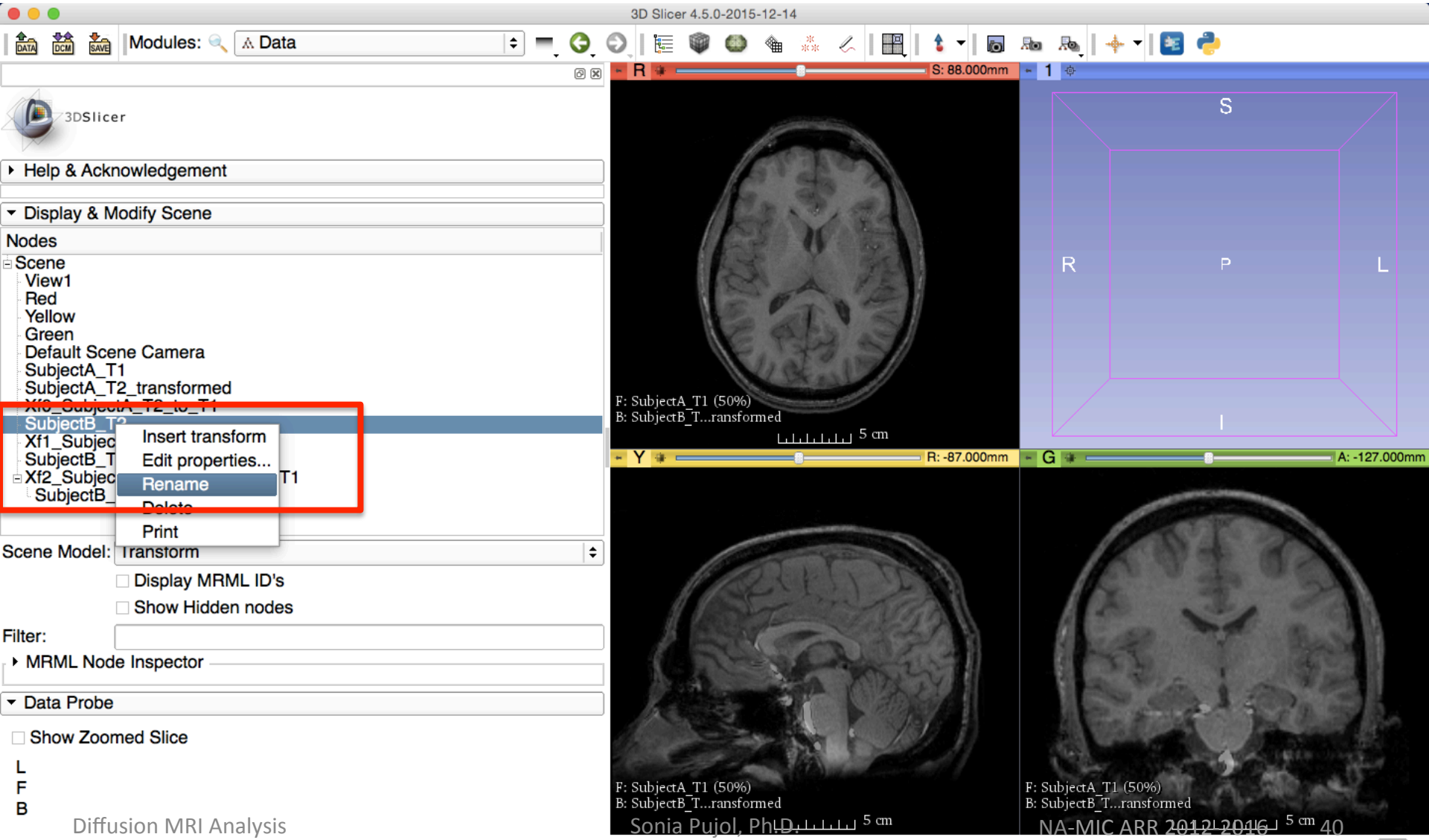
Rename Transformed Volume



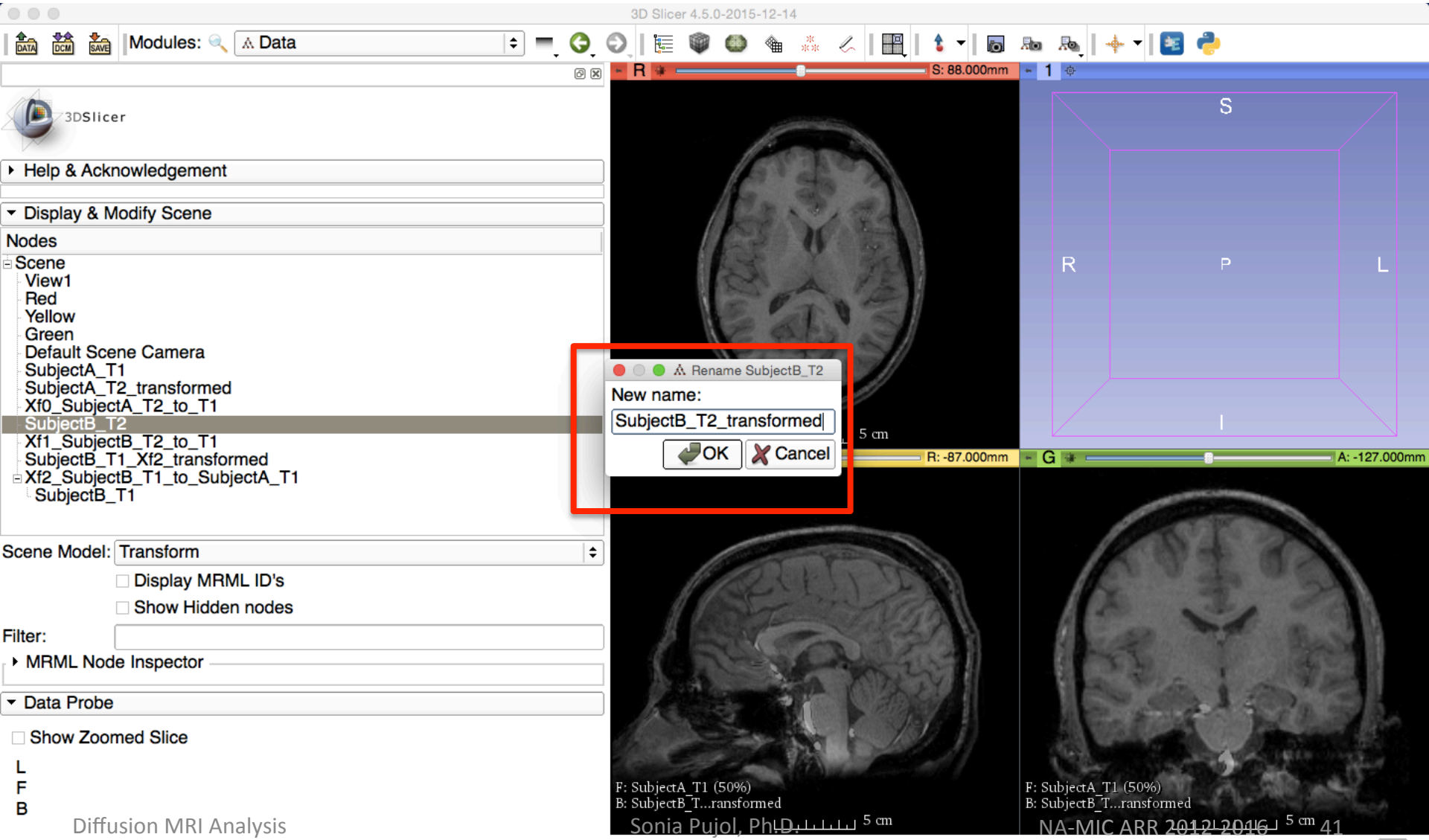
Harden Transform Xf1 (Subject B: T2 to T1)



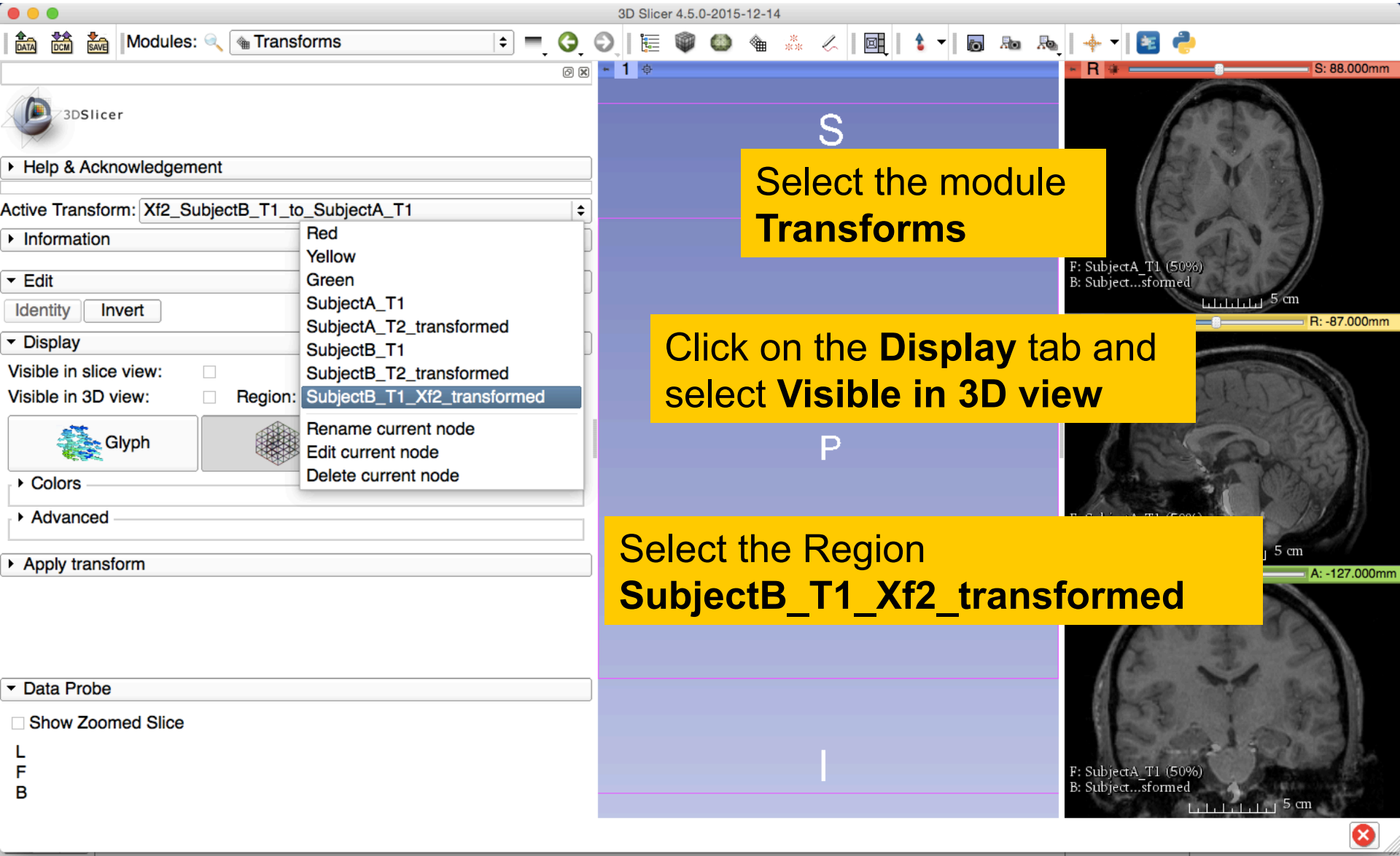
Renamed Transformed Volume



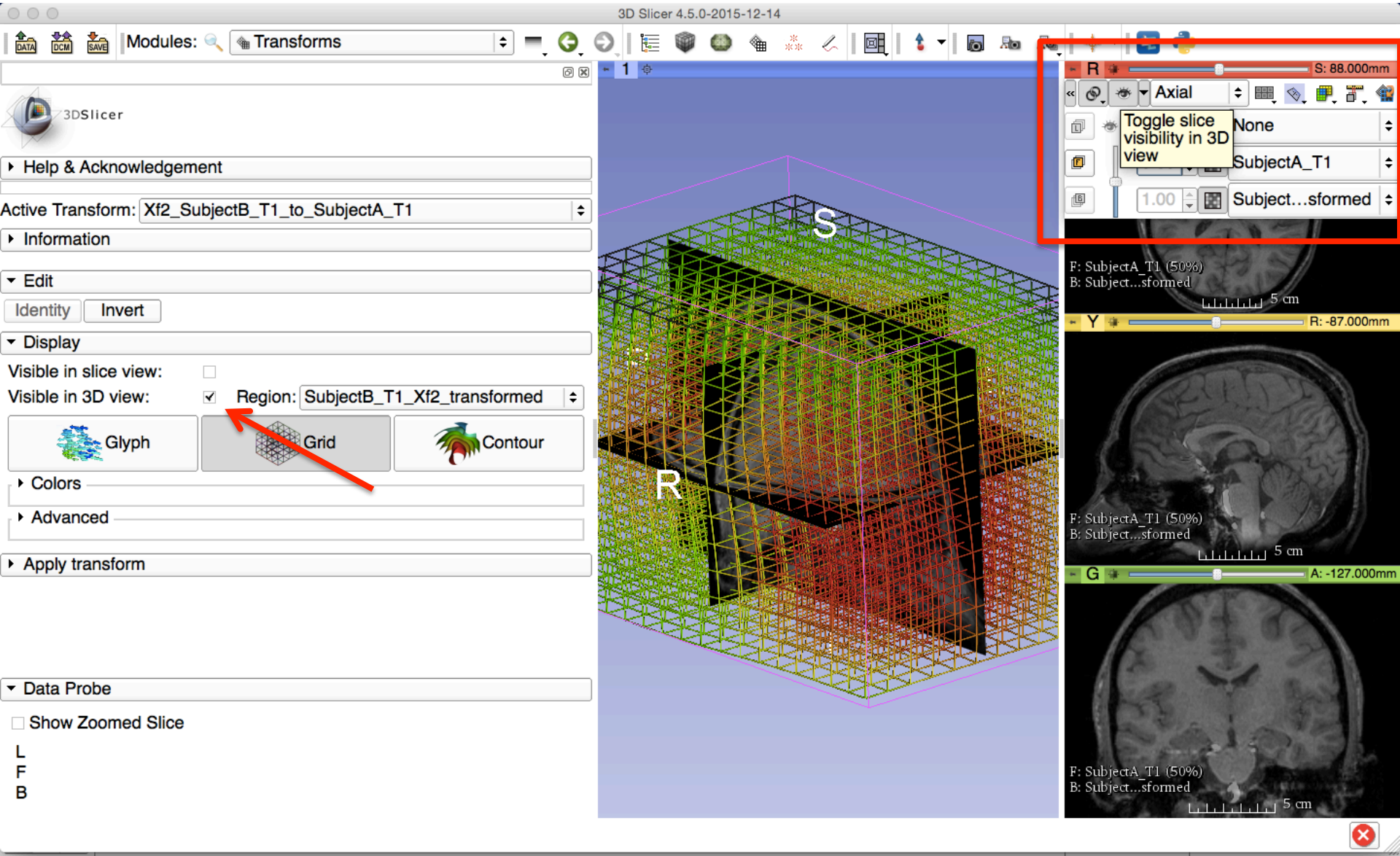
Rename Transformed Volume



Visualizing Xf3 (Subject B T1 to Subject A T1)



Visualizing Xf3 (Subject B T1 to Subject A T1)



Acknowledgments

- National Alliance for Medical Image Computing (NA-MIC)

  NIH U54EB005149

- Neuroimage Analysis Center (NAC)

  NIH P41RR013218

- Fan Zhang, University of Sydney Australia