NA-MIC
National Alliance for Medical Image Computing
http://www.na-mic.org

Segmentation for 3D printing

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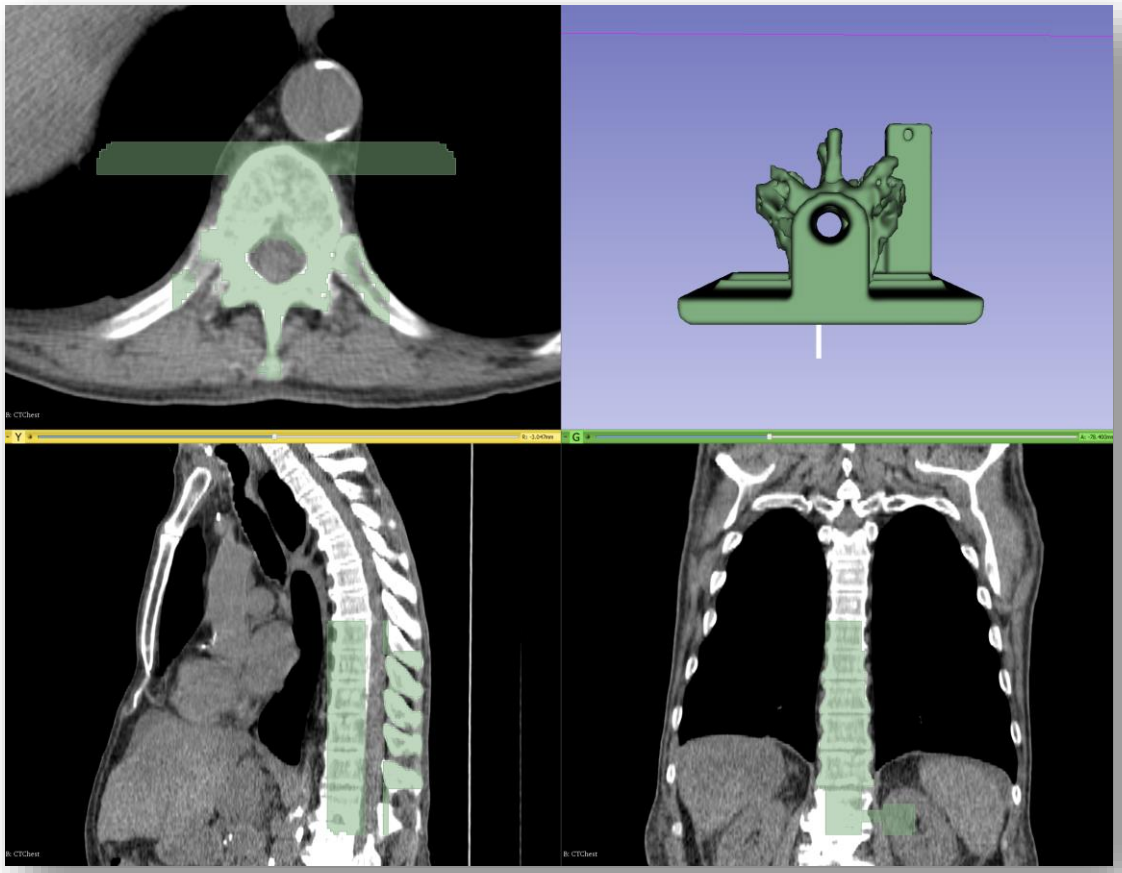
NA-MIC Tutorial Contest: Winter 2017

Learning Objective

This tutorial demonstrates segmentation in Slicer's new Segment Editor module for the purpose of 3D printing



Clinical utility of the created spine phantom

- Training phantom for needle insertion
- Electromagnetic marker holder
- Filled with gel (~soft-tissue)
- Covered with sheet (~skin)
- Tube with water in the center

Moult et al. 2013

Material

This tutorial requires the installation of a recent Slicer 4.7 nightly release, which is available at the

Slicer download page:

http://download.slicer.org/ (see row of Nightly Build)

Tutorial dataset: Phantom base STL model

http://www.na-mic.org/Wiki/images/1/1e/BasePiece.stl (source: PerkLab)

Wiki pages:

https://www.slicer.org/wiki/Documentation/Nightly/Modules/Segmentations

https://www.slicer.org/wiki/Documentation/Nightly/Modules/SegmentEditor

Platforms

- Developed and maintained on Windows 64bit, Mac OSX, and Linux 64bit & 32bit



- Slicer requires
  - Minimum 2GB RAM
  - 64 bit strongly suggested

Segment Editor module

- Successor of the ‘Editor’ module
- In addition to Editor it provides
  - real-time 3D surface update
  - editing on oblique slices
  - overlapping segments, and much more
- It is considered stable
  - But development is still underway

Overview

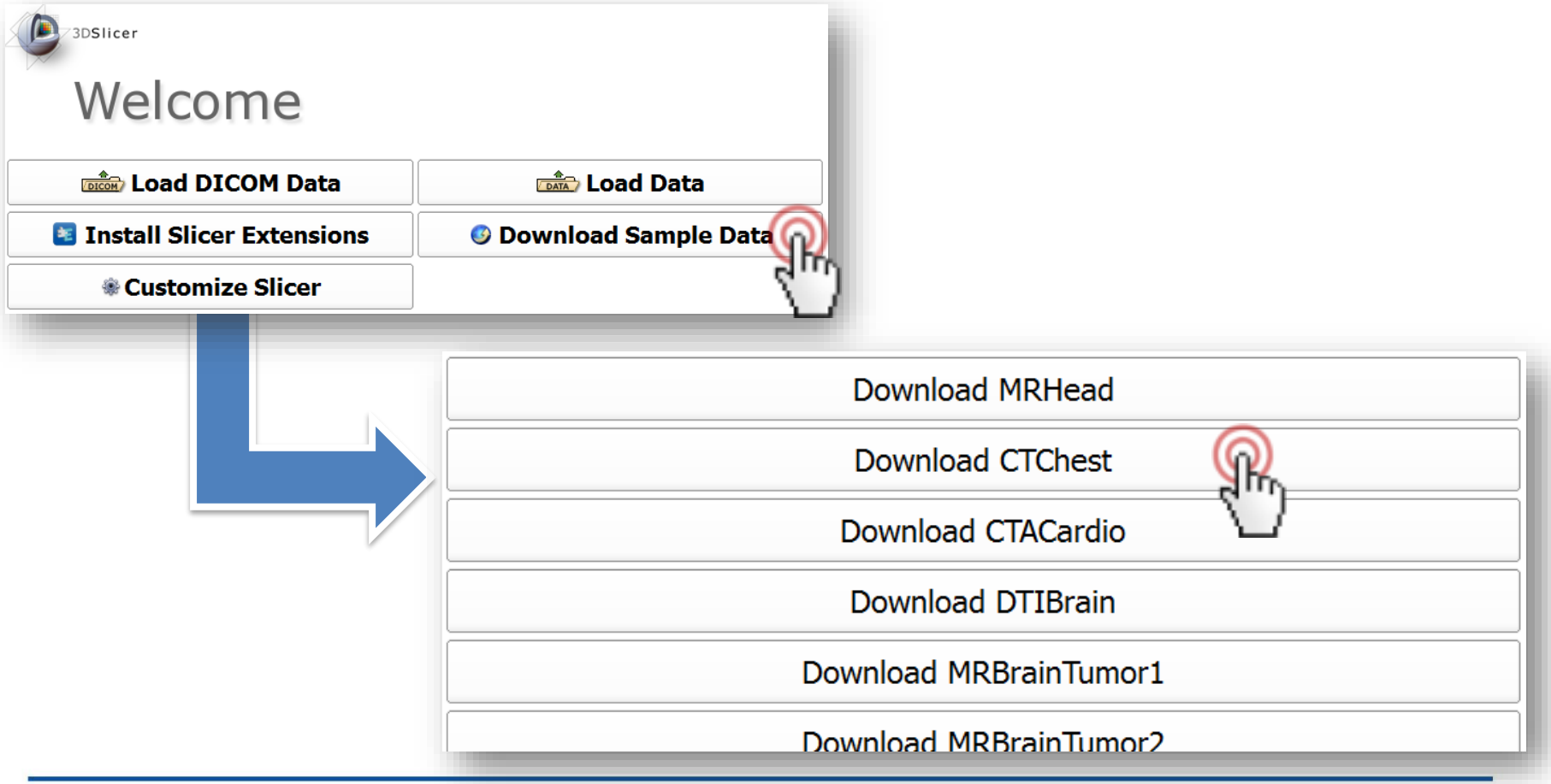
1. Load CT image
2. Segment vertebrae to be 3D printed
3. Add phantom base to segmentation
4. Merge and finalize phantom
5. Save phantom segment to STL file for 3D printing

Part 1: Load CT image

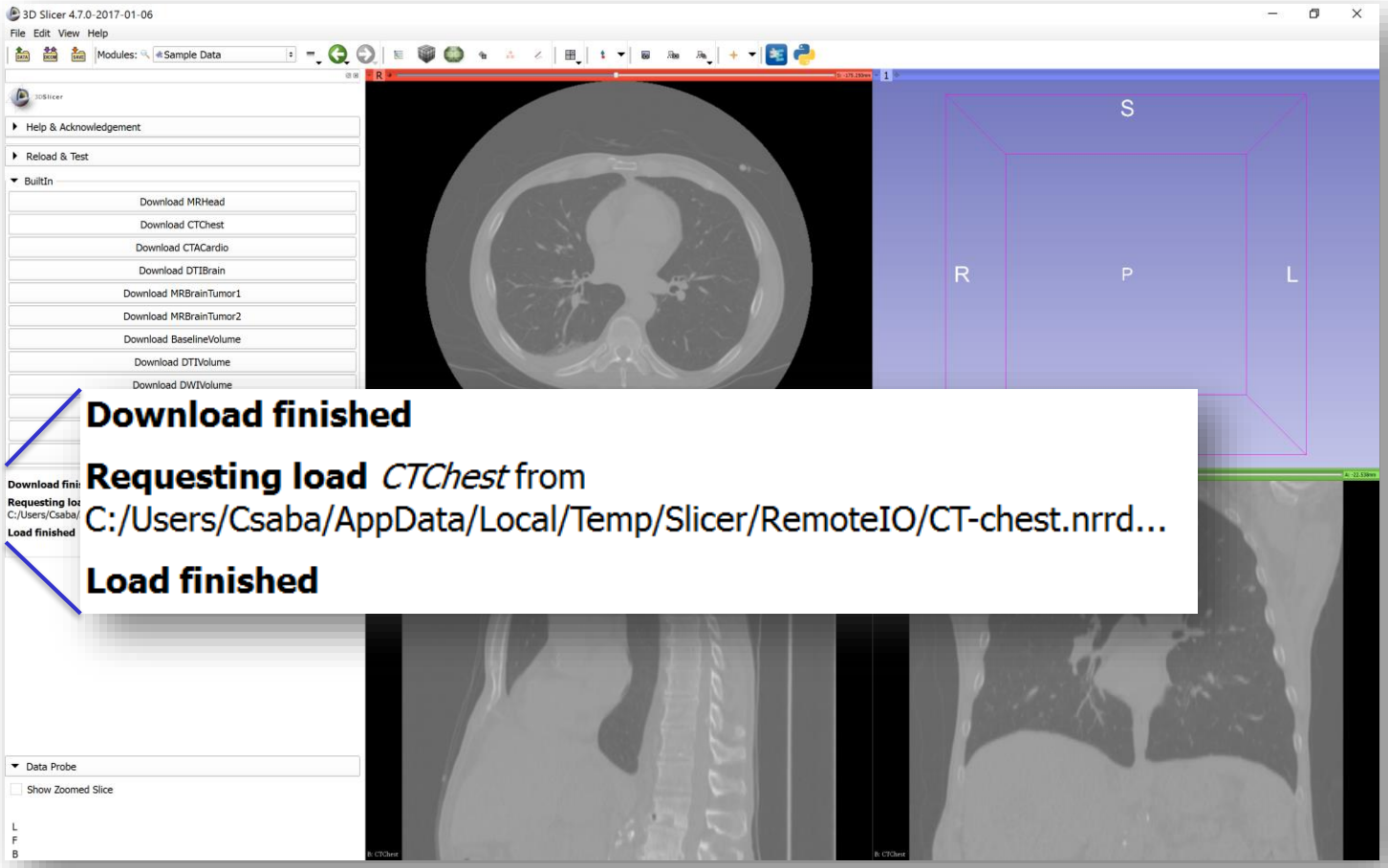
Overview:

- Load sample CTChest dataset
- Set image contrast for better visibility

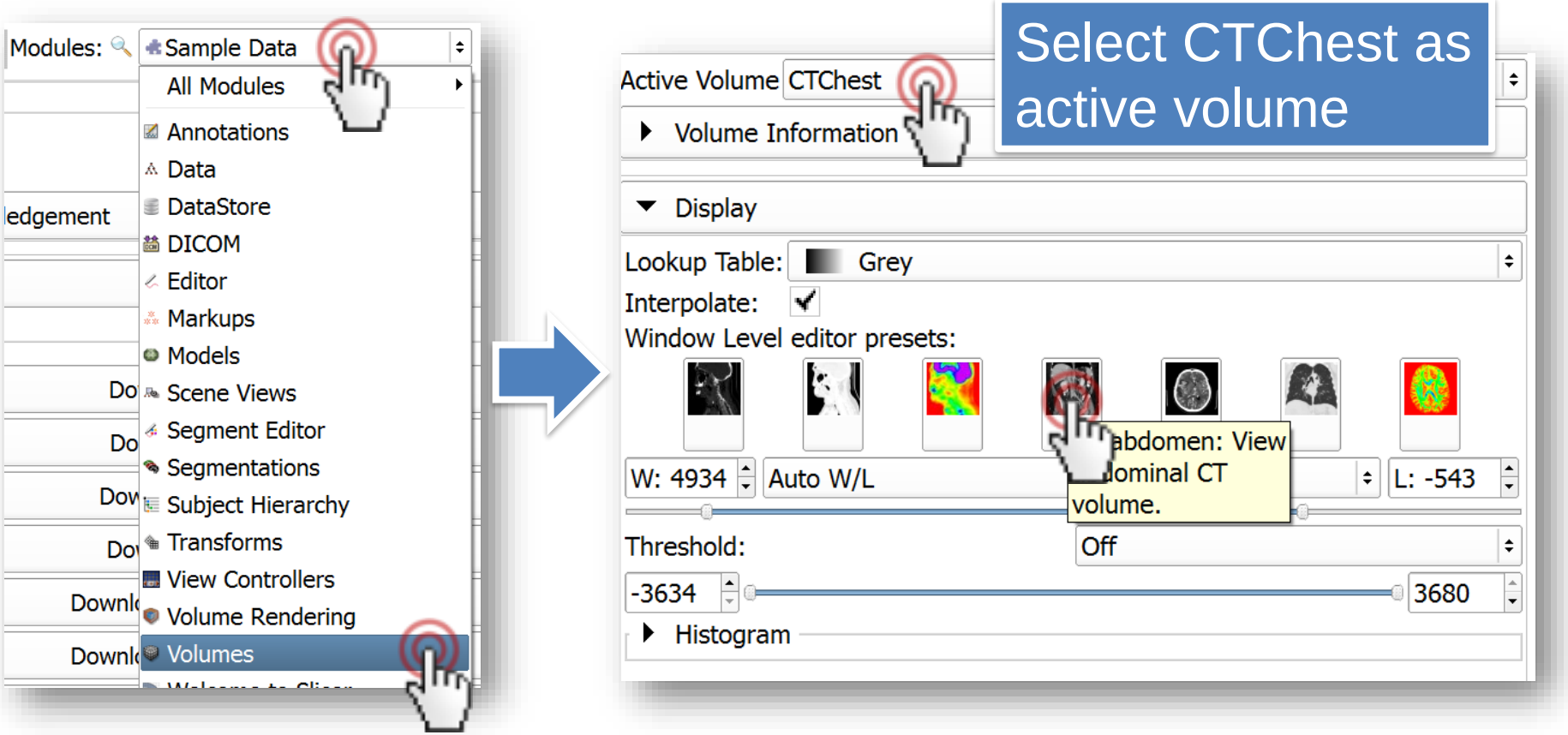
1/1: Load CTChest dataset



1/2: Sample CT loaded



1/3: Change contrast

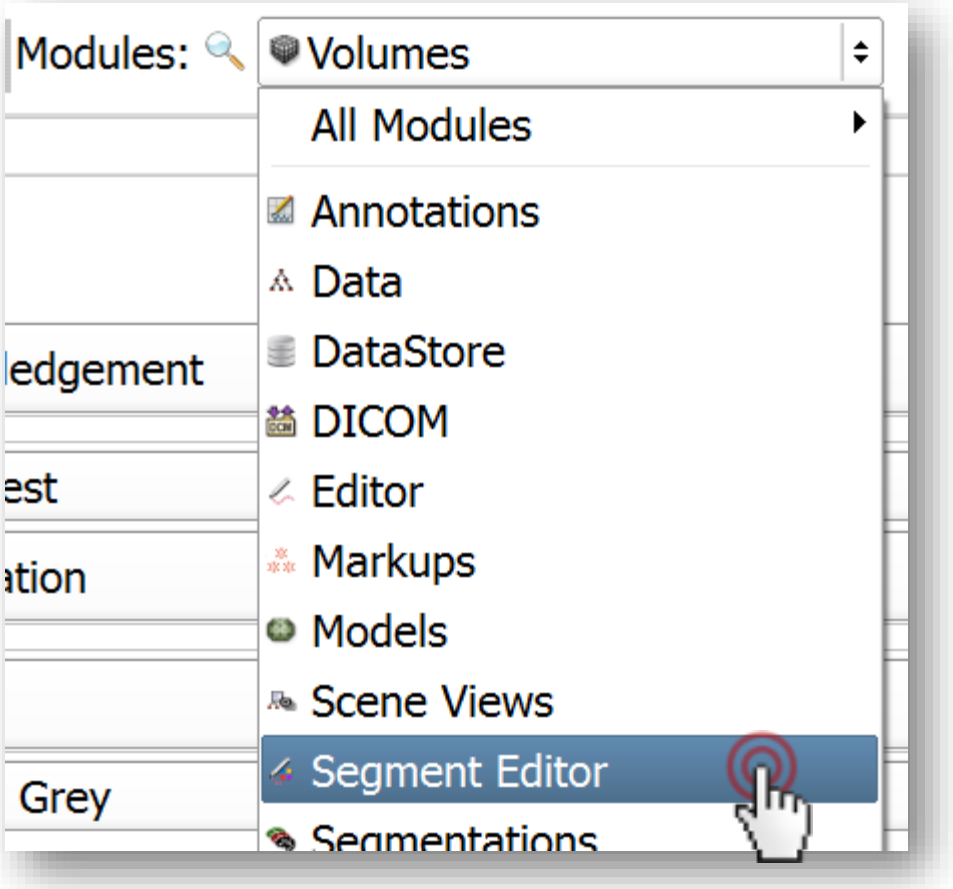


Part 2: Segment vertebrae

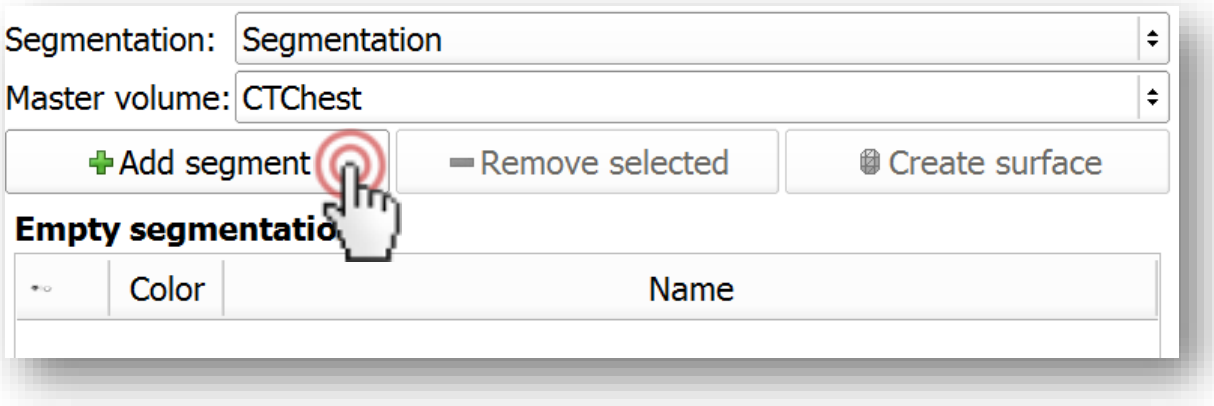
Overview:

- Add new segment
- Threshold bone
- Remove speckles with Islands
- Cut out vertebrae with Scissors

2/1: Switch to Segment Editor module



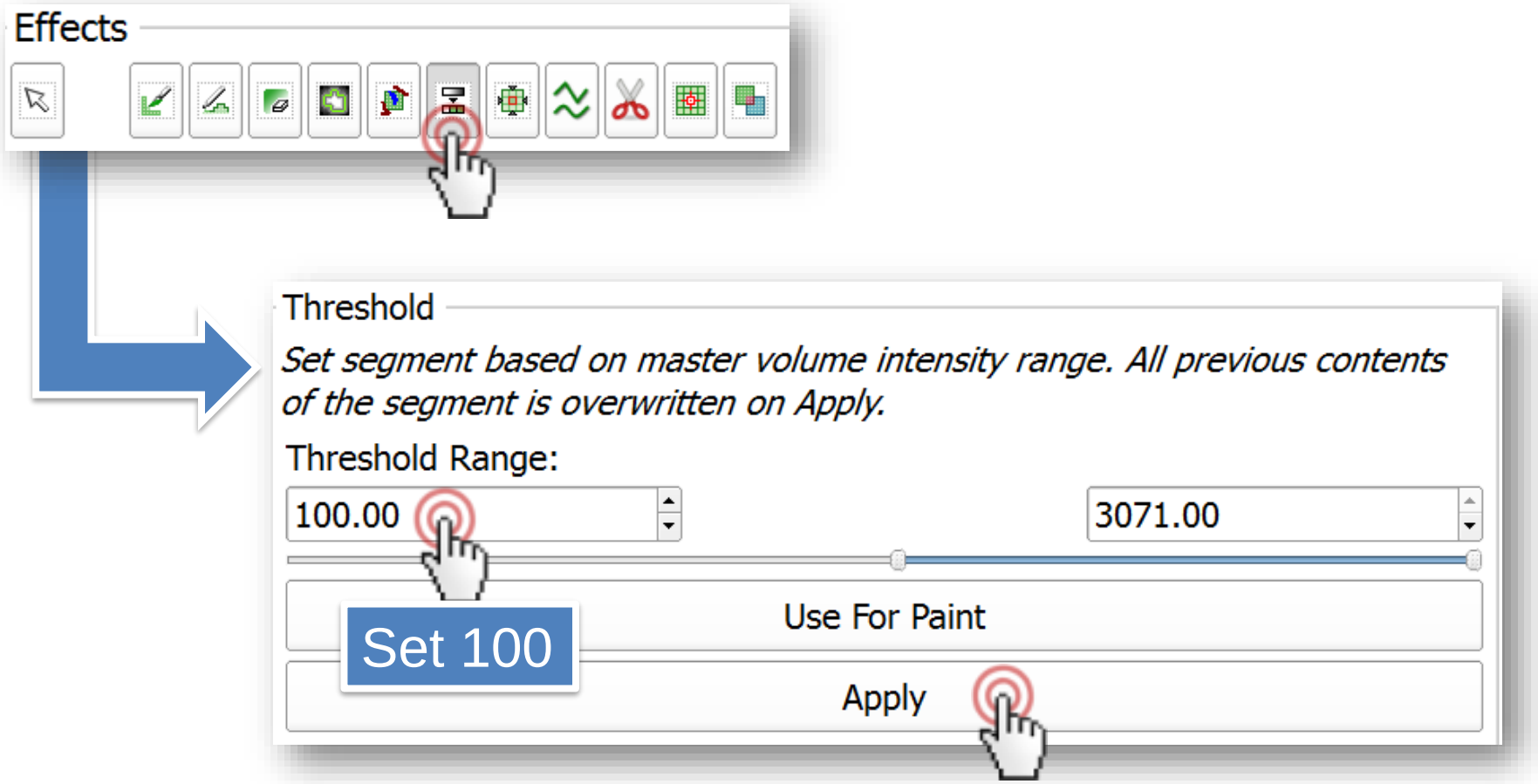
2/2: Add new segment



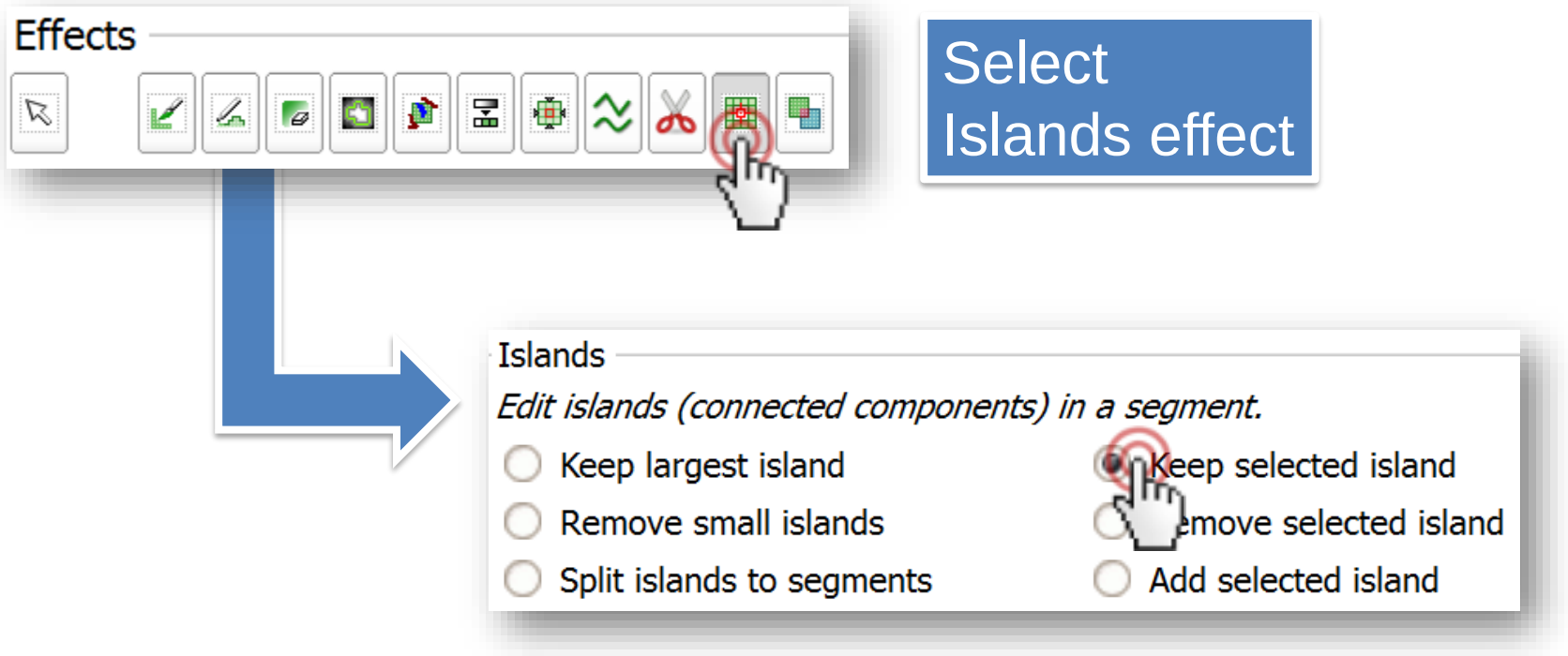
- Segmentation automatically created
- CT volume automatically selected as master

(Master is the segmented volume that defines the resolution of the segments)

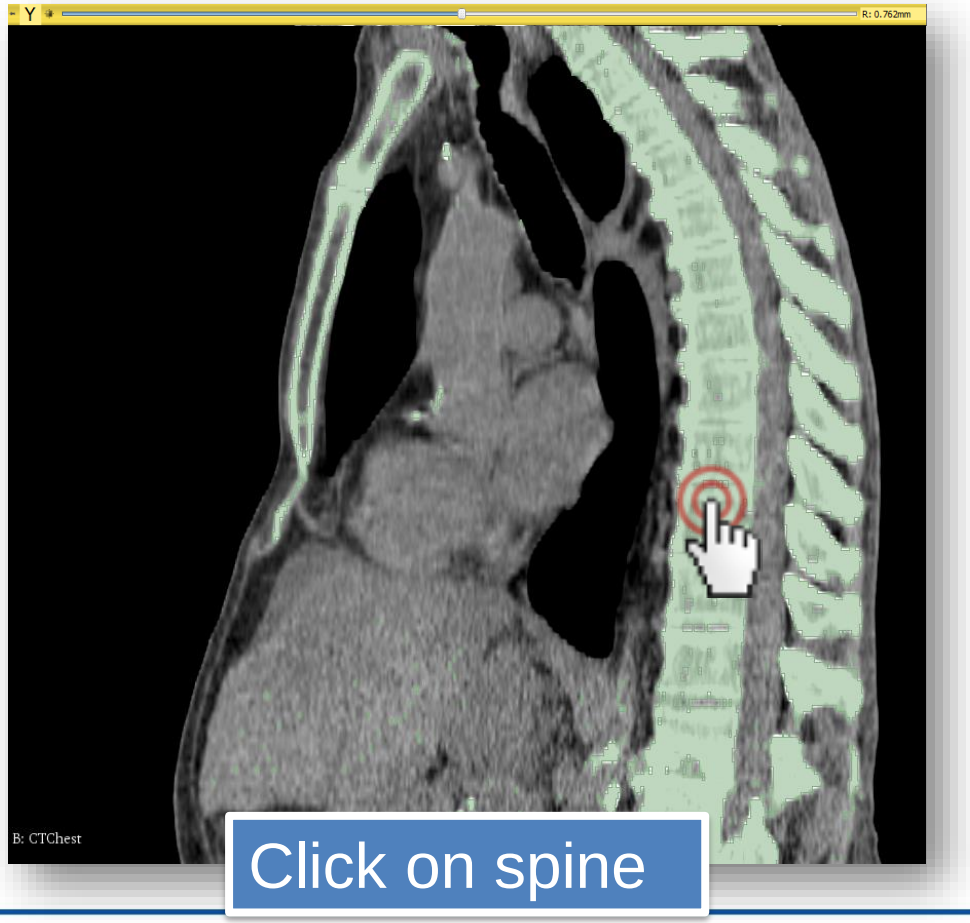
2/3: Threshold to get bone



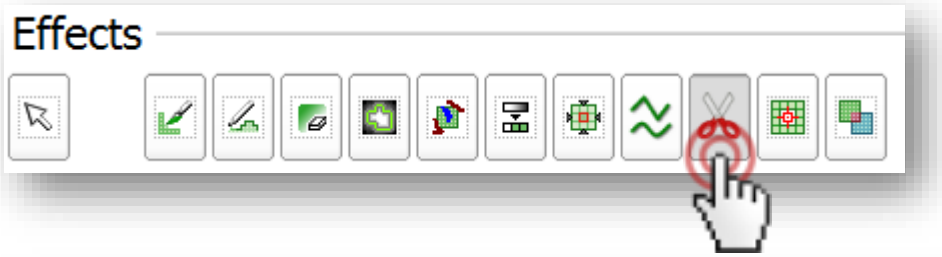
2/4: Remove speckle with the Islands effect

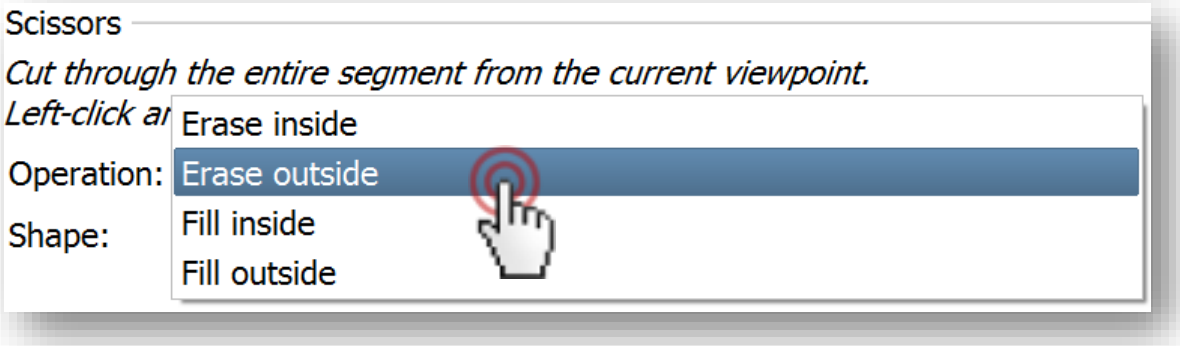


2/5: Remove speckle with the Islands effect



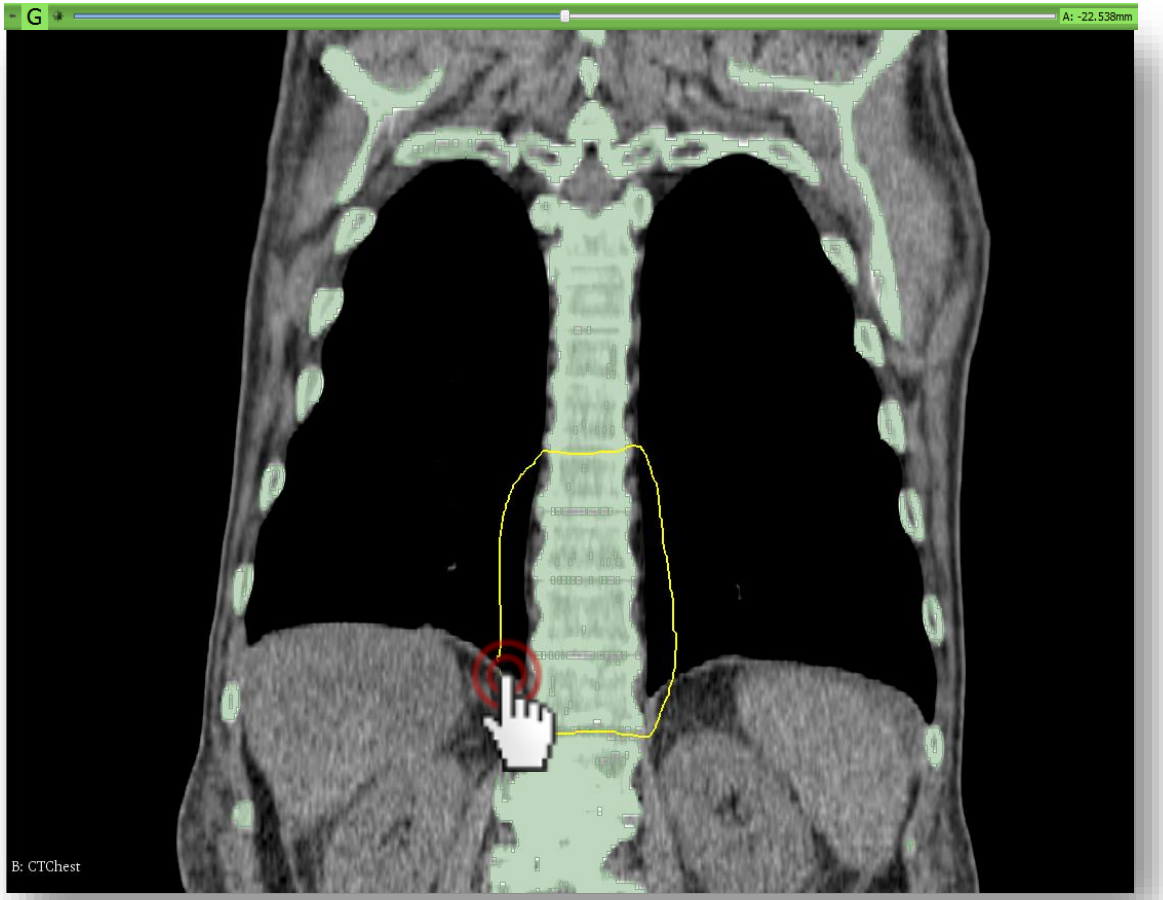
2/6: Cut out vertebrae with the Scissors effect





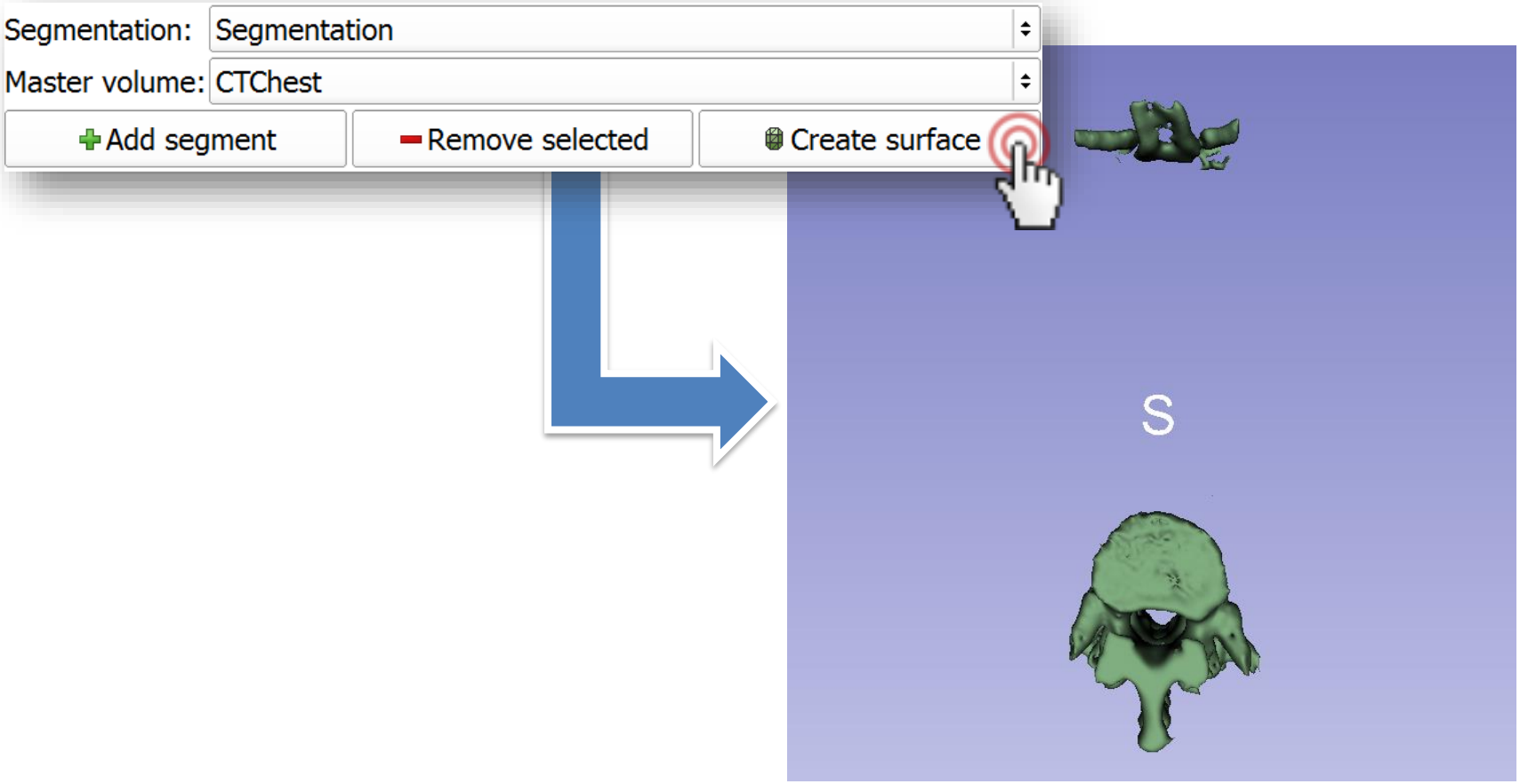
1. Select Scissors effect
2. Choose ‘Erase outside’ as operation
3. Choose ‘Free-form’ shape

2/7: Cut out vertebrae with the Scissors effect

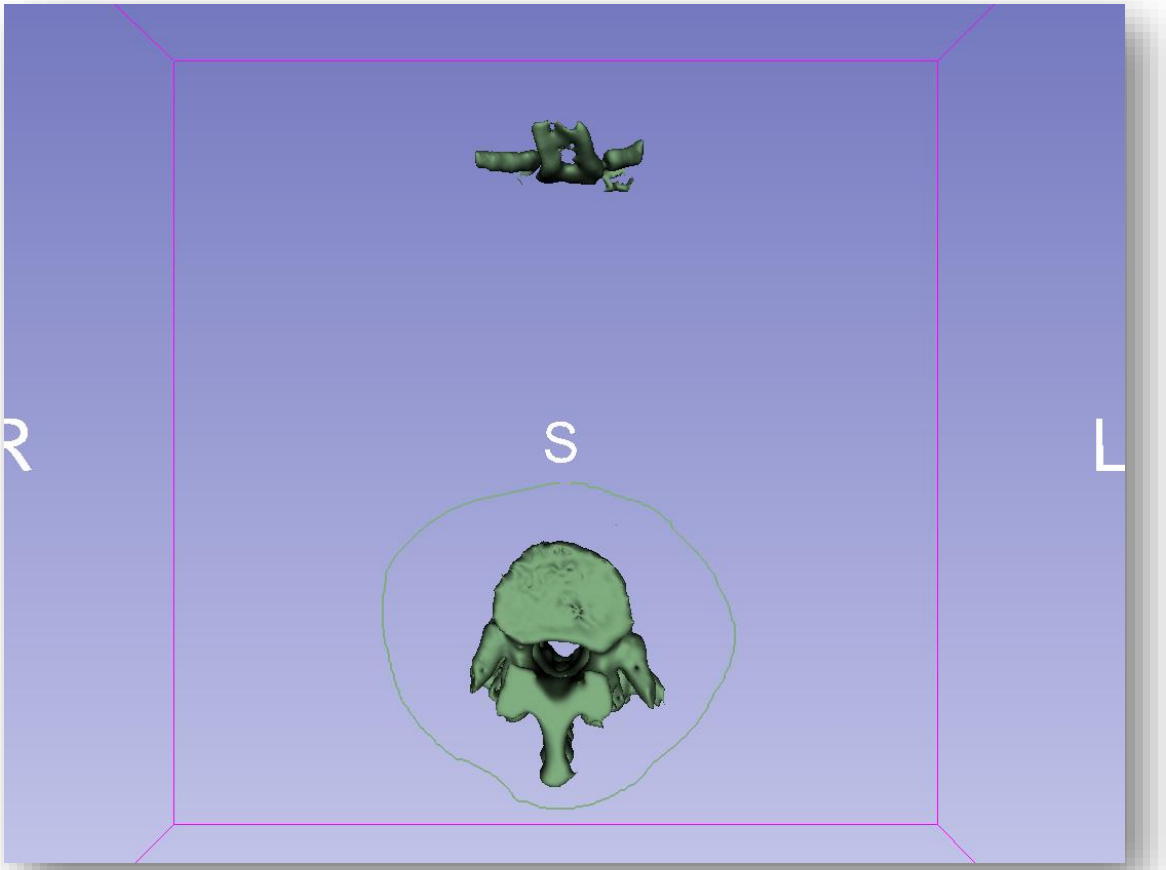


Trace around the desired vertebrae with the scissor on the coronal view (green slice)

2/8: Show segment as surface in 3D view

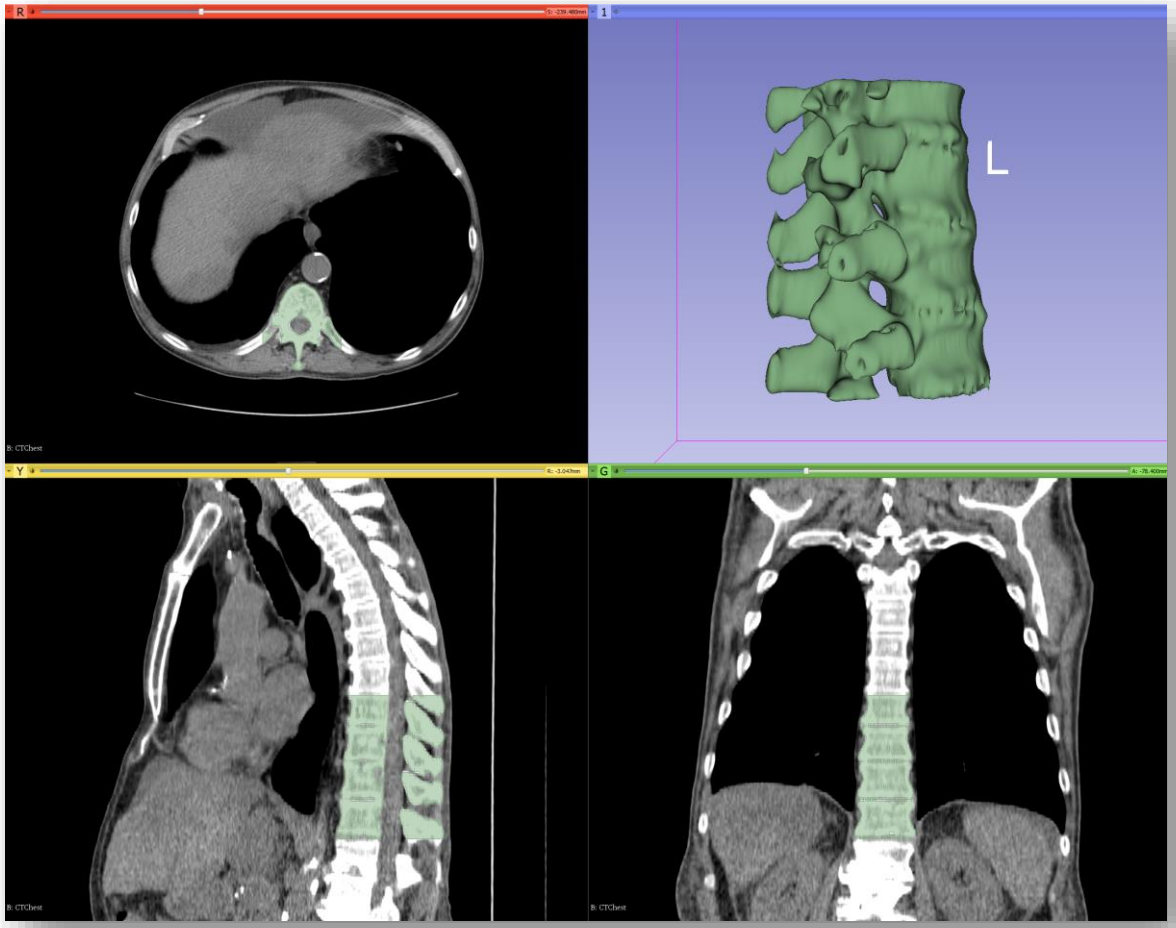


2/9: Remove remaining parts with Scissors



Select the vertebrae in the 3D view to erase the remaining parts (ribs on the anterior side in this case)

2/10: Vertebrae are segmented



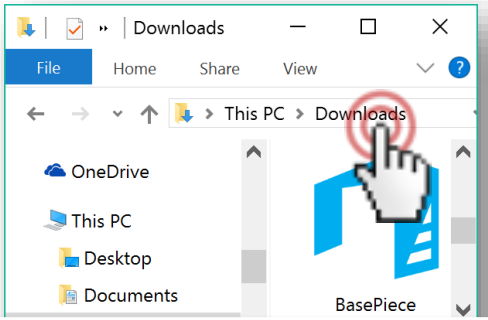
Part 3: Add phantom base

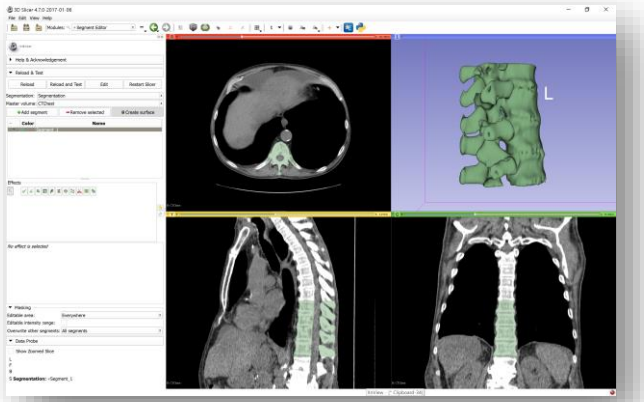
Overview:

- Load phantom base STL file
- Transform model to desired position and orientation
- Import model to segmentation node
- Cut hole through middle of the spine

3/1: Load phantom base as model node

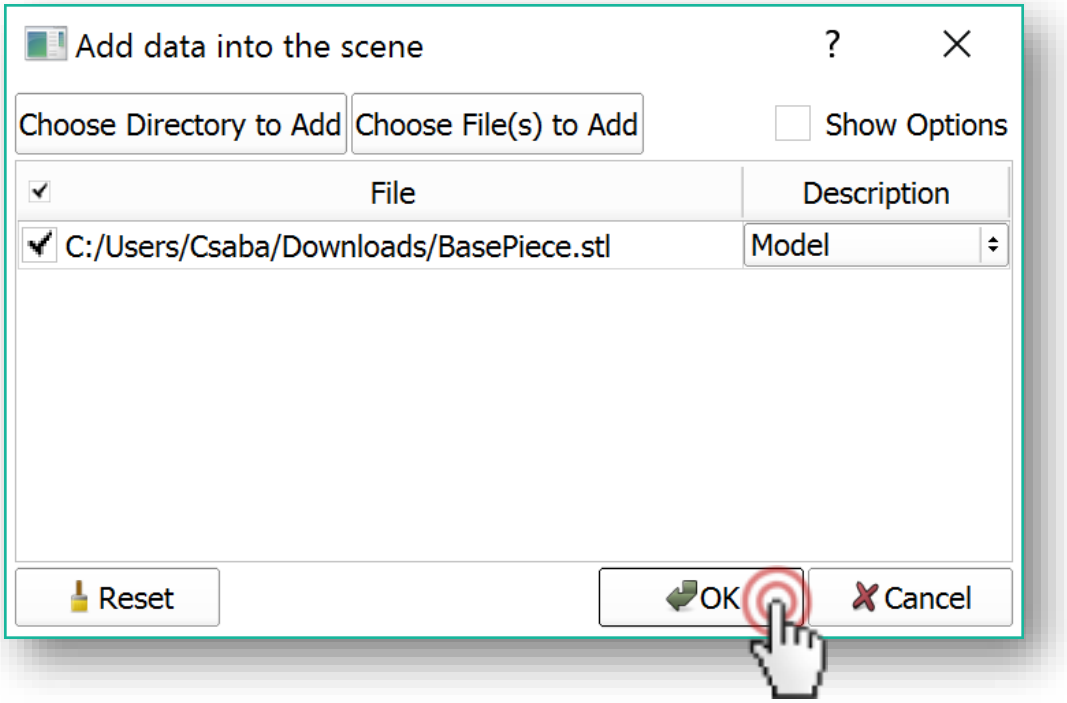
Download phantom base STL file from
http://www.na-mic.org/Wiki/images/1/1e/BasePiece.stl



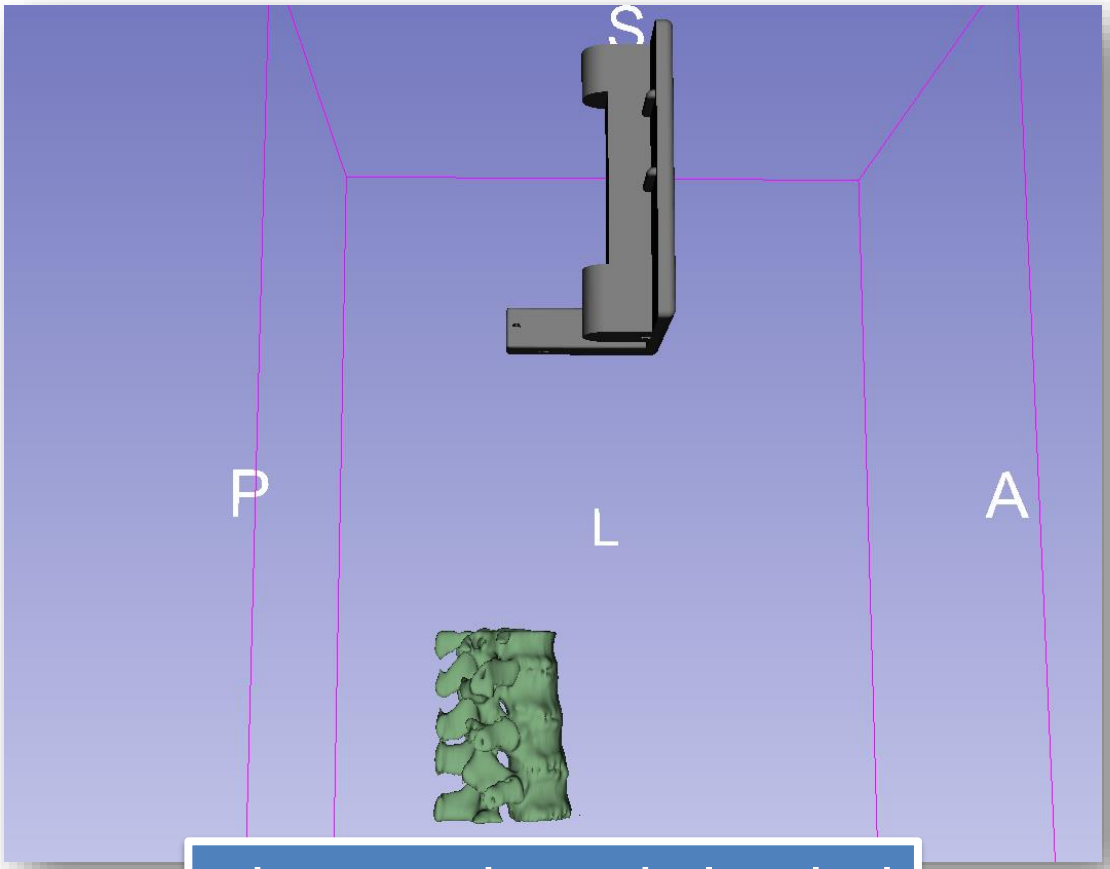


Drag&drop ‘BasePiece.stl’ onto the Slicer

3/2: Load phantom base as model node



3/2: Load phantom base as model node

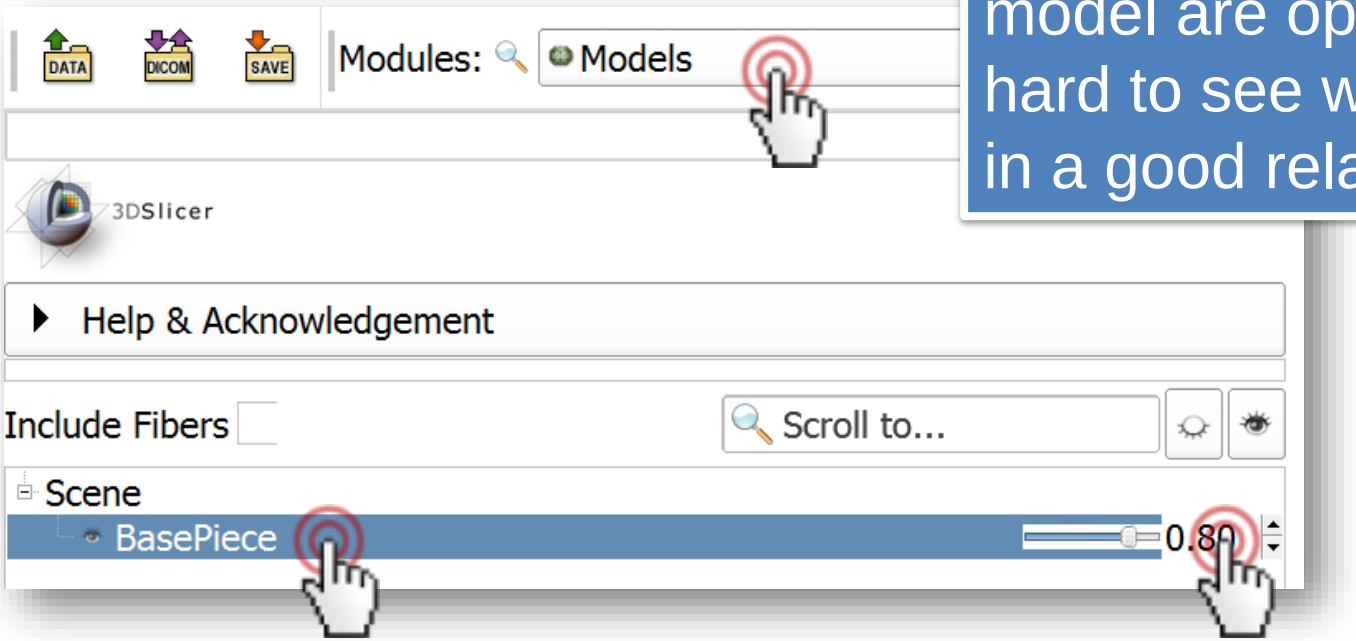


Phantom base is loaded

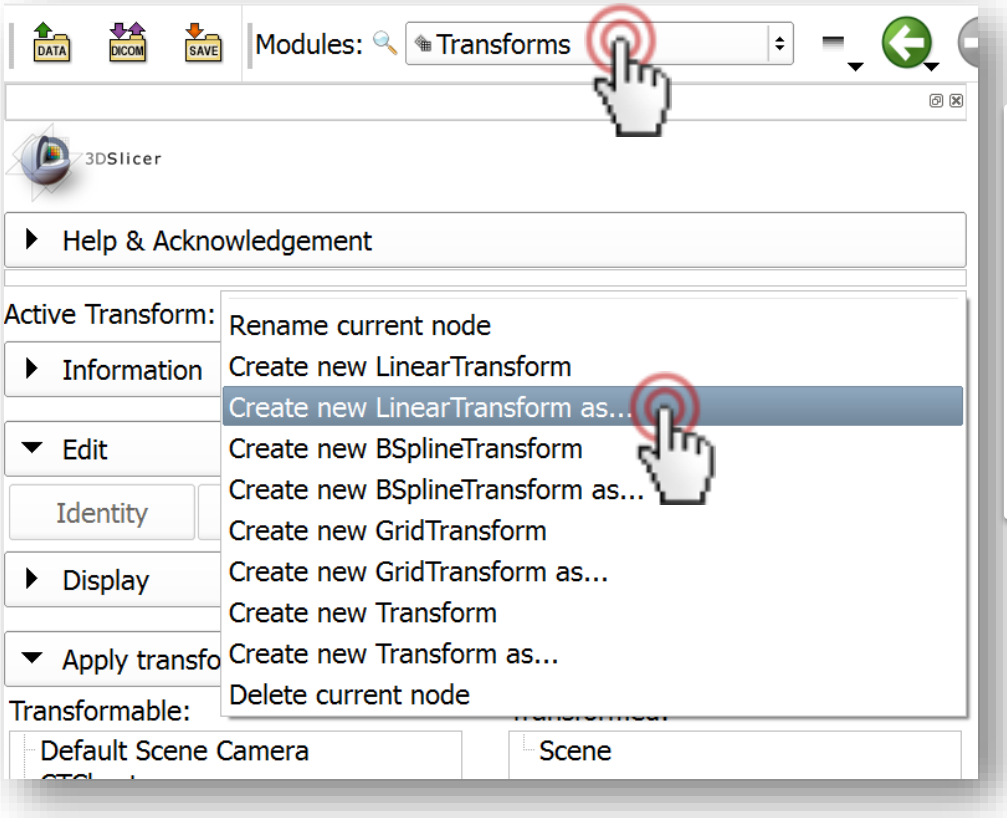
3/1: Make base semi-transparent in Models

1. Switch to Models module
2. Decrease opacity to 0.8

When both the segmentation and the model are opaque, it is hard to see when they are in a good relative position

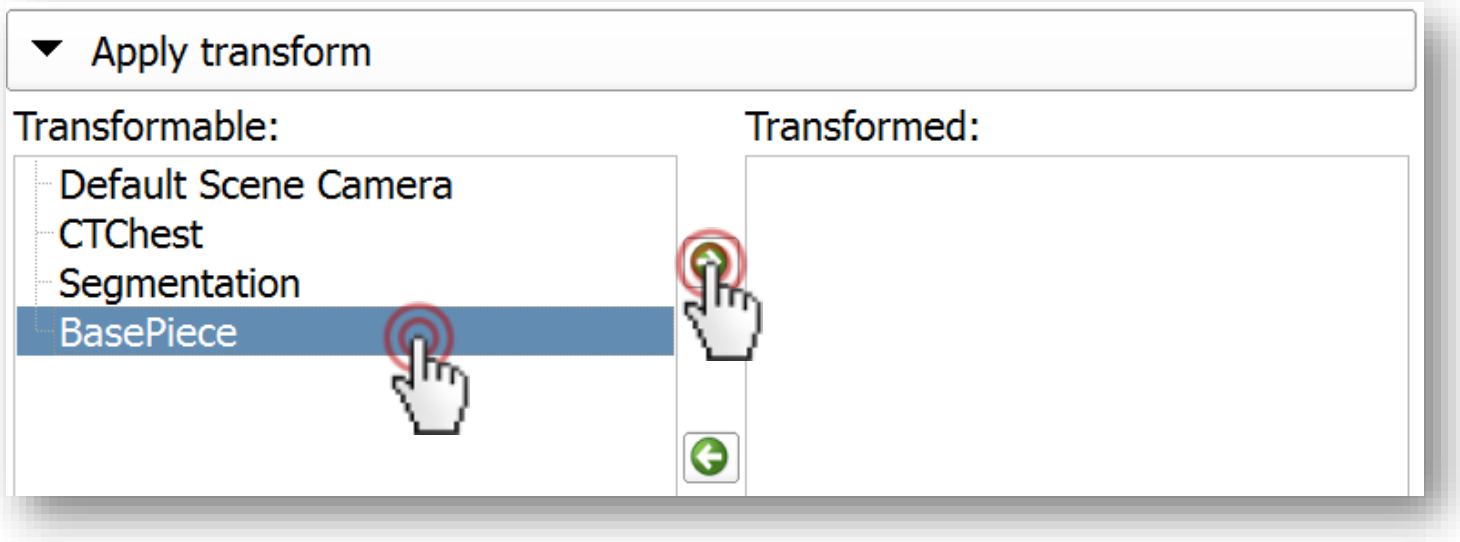


3/2: Create transform



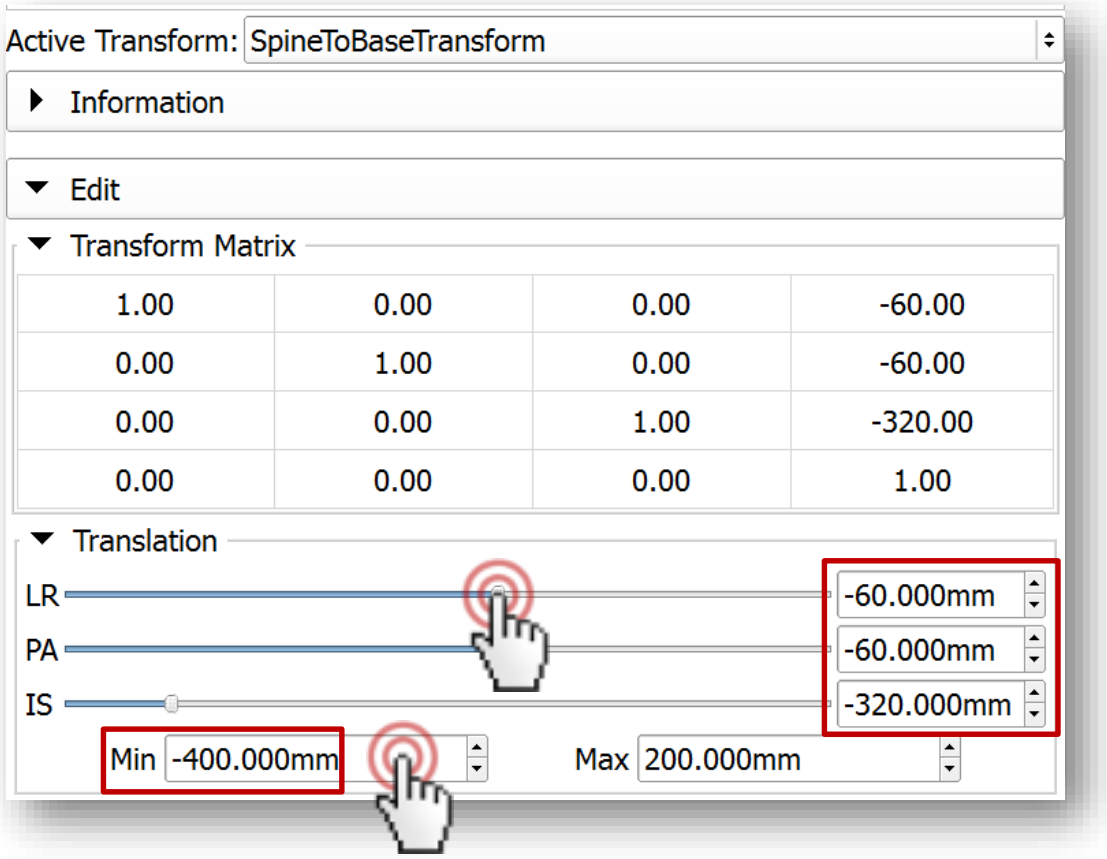
1. Switch to Transforms module
2. Create linear transform
3. Name it ‘SpineToBaseTransform’

3/3: Apply transform to base



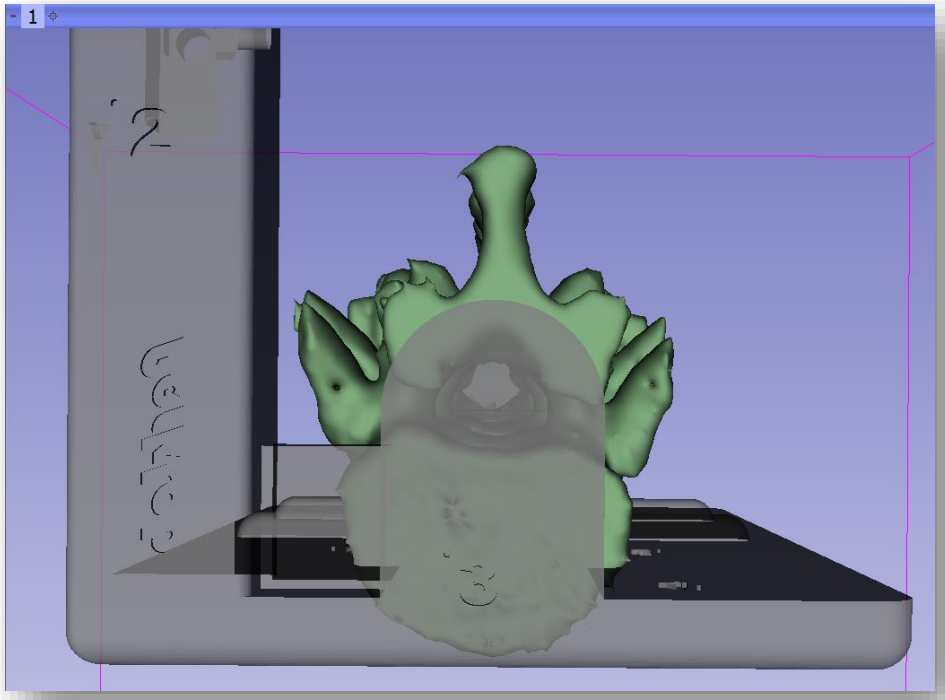
1. Select base piece
2. Move it under the tansform

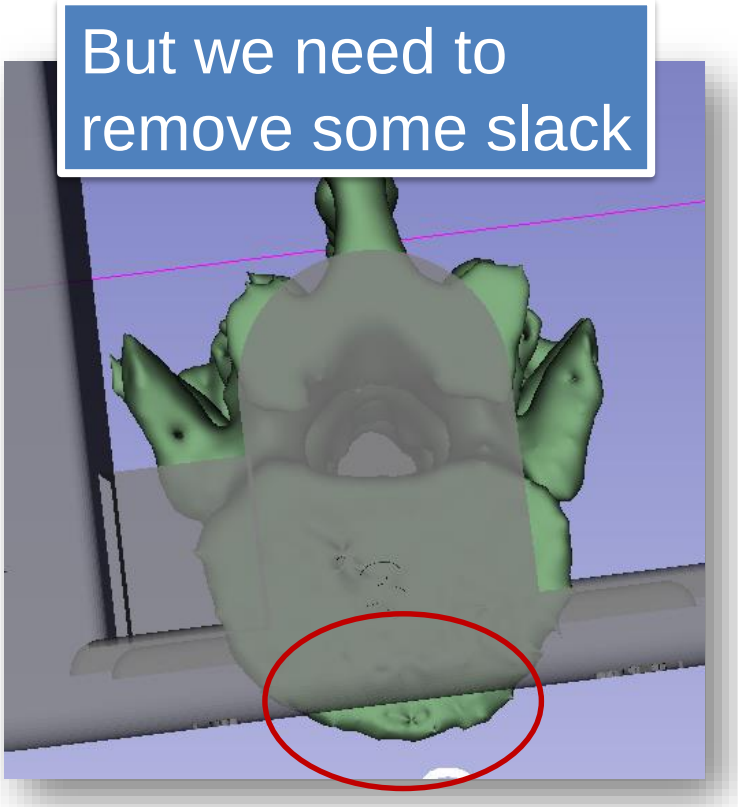
3/5: Move base into place



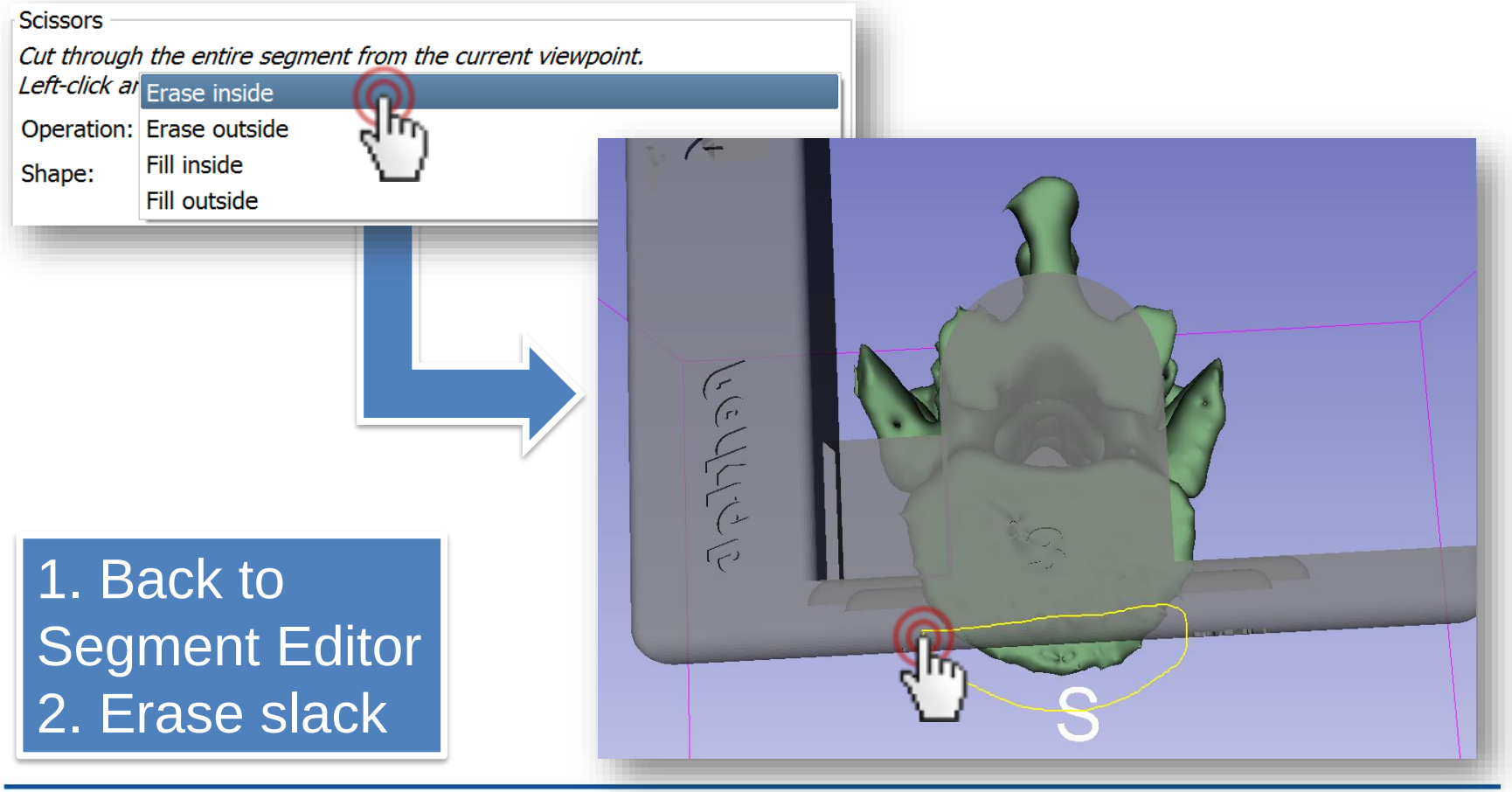
1. Decrease minimum value to -400
2. Move sliders until the base is in the correct position (values in picture are the final ones)

3/6: Base is in the correct position





3/7: Use Scissors effect to remove slack



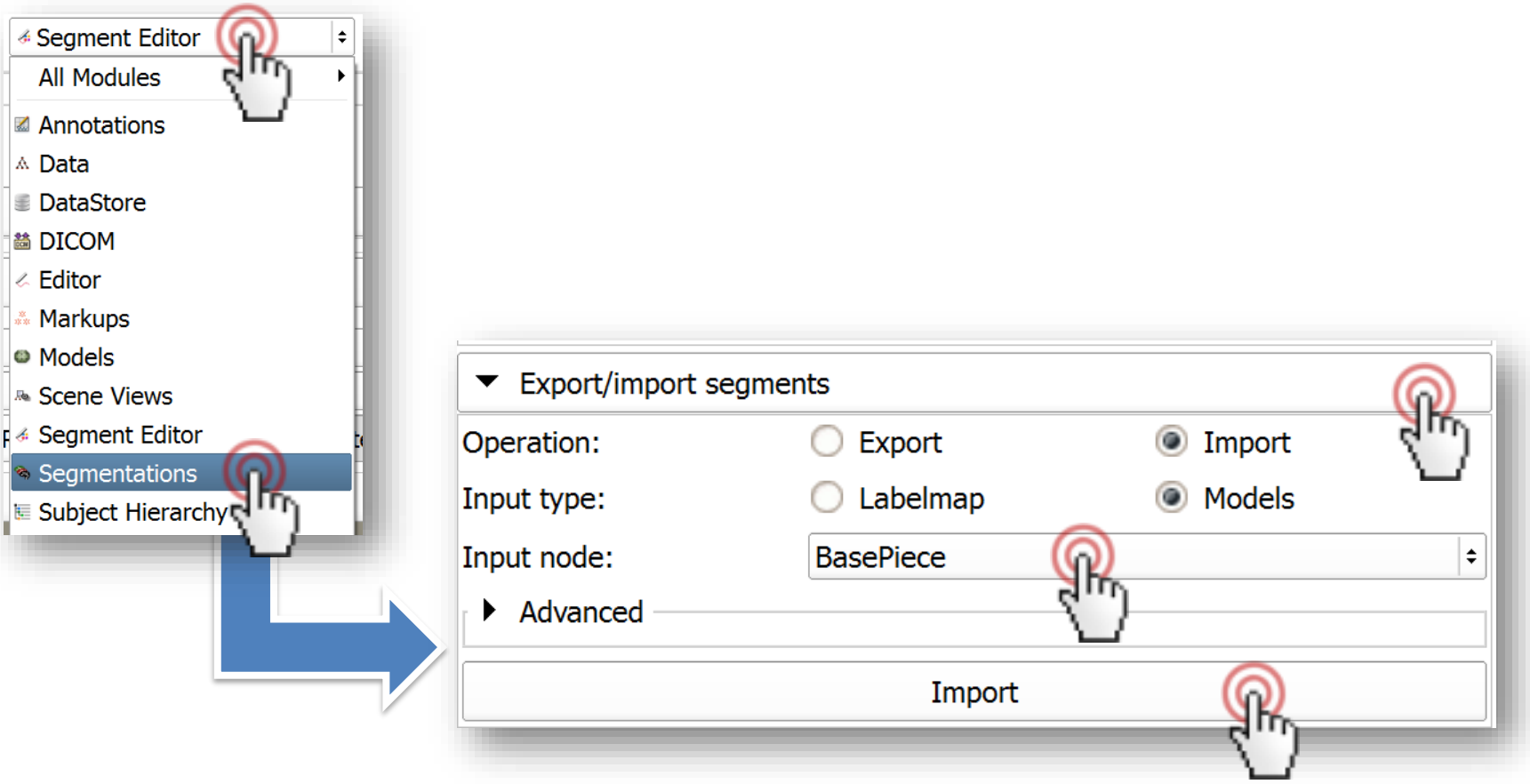
1. Back to Segment Editor
2. Erase slack

Part 4: Merge and finalize phantom

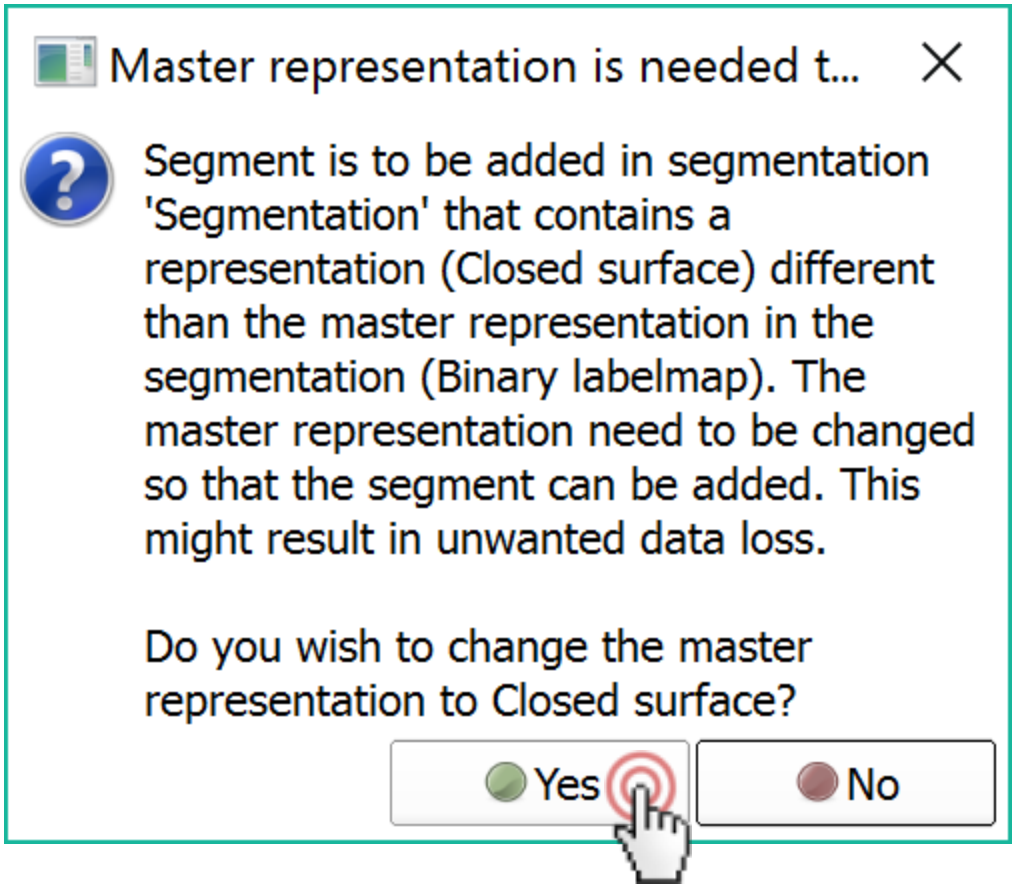
Overview:

- Create segmentation from base piece
- Copy base piece segment into vertebrae segmentation
- Merge two segments
- Cut hole through phantom

4/1: Import base into segmentation

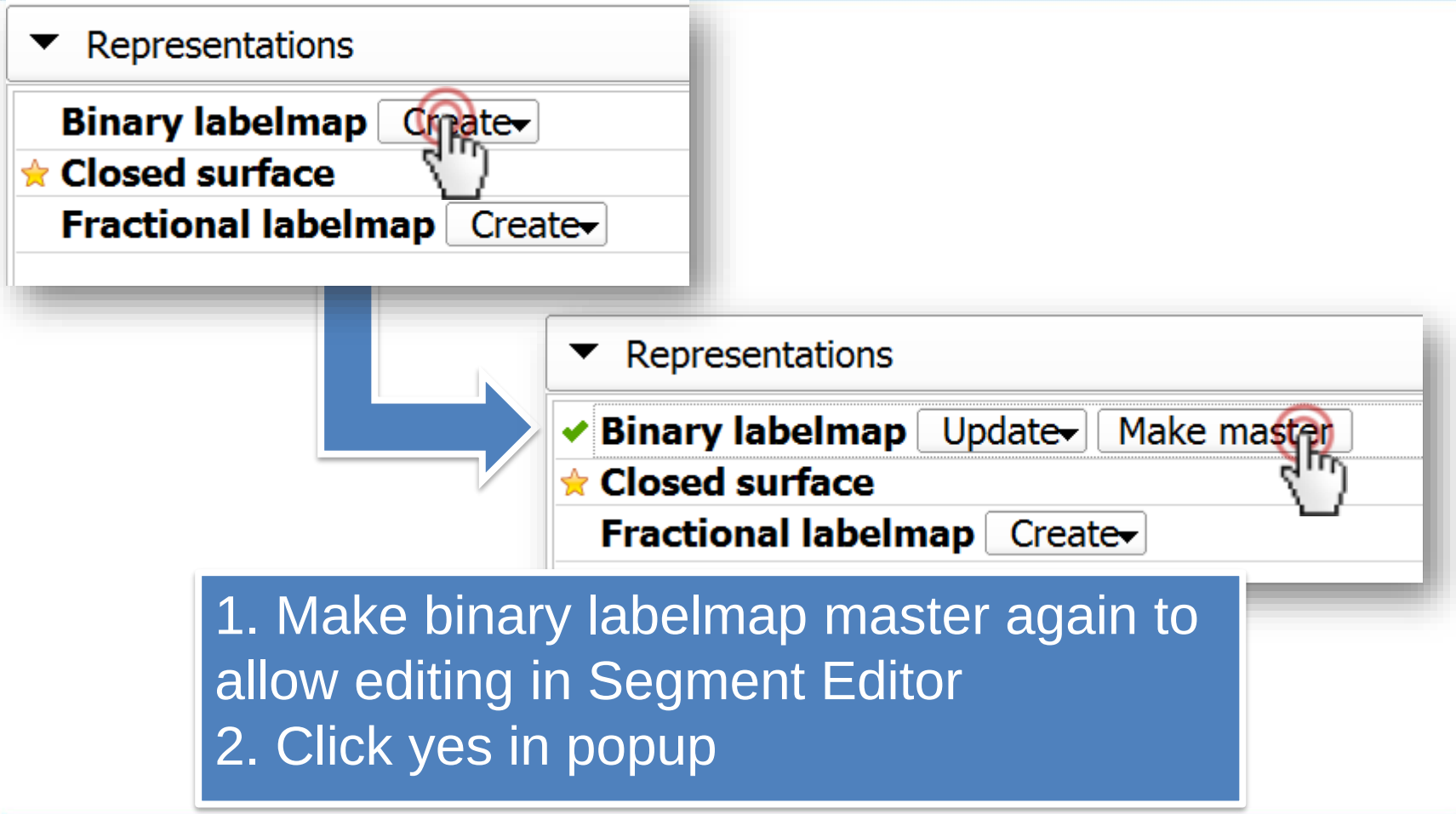


4/2: Import base into segmentation



Base piece is a surface, and the vertebrae were created as labelmaps. Convert to surface to allow import

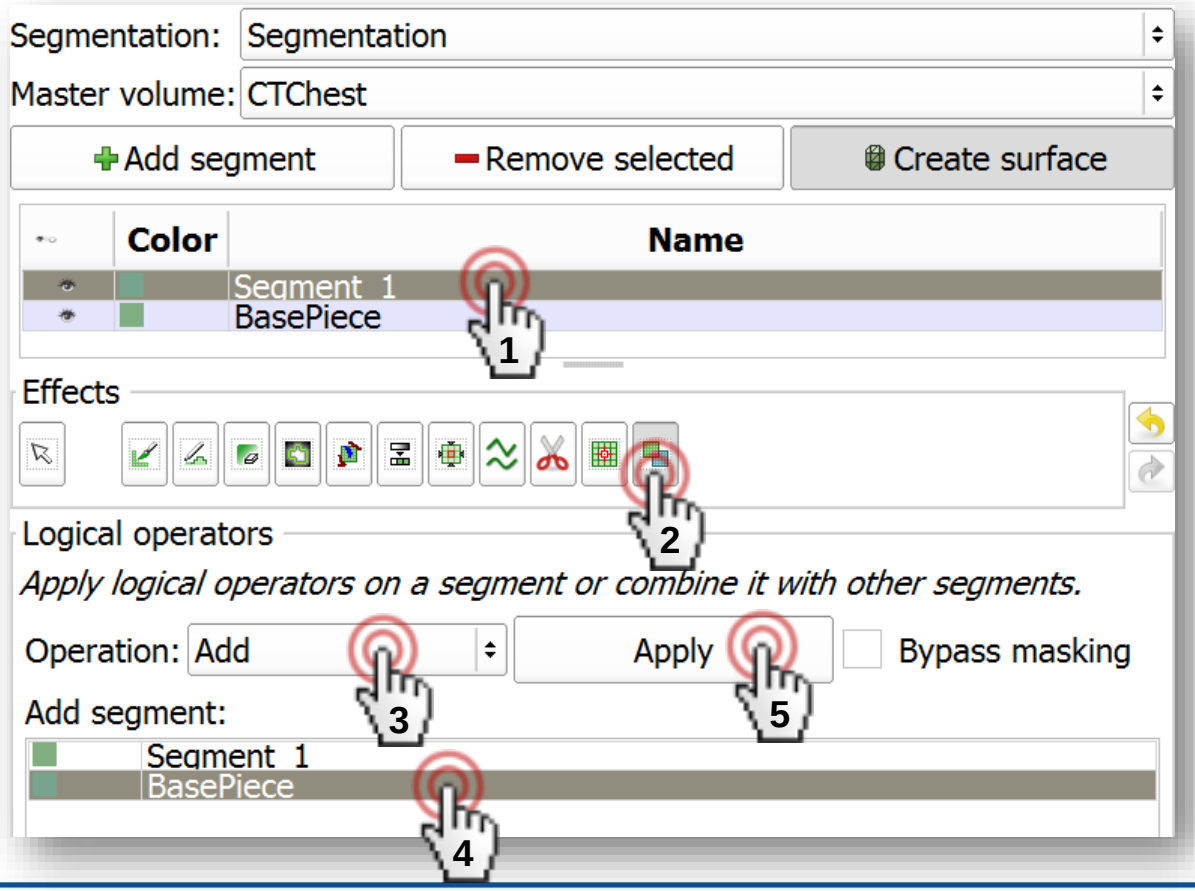
4/3: Convert back to labelmap to allow editing



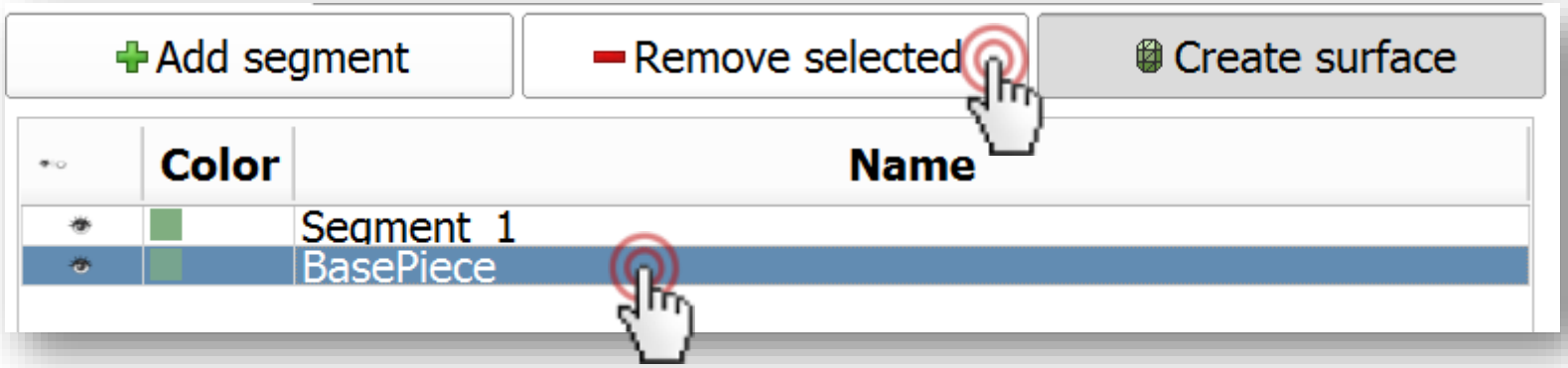
1. Make binary labelmap master again to allow editing in Segment Editor
2. Click yes in popup

4/4: Merge the two in Segment Editor

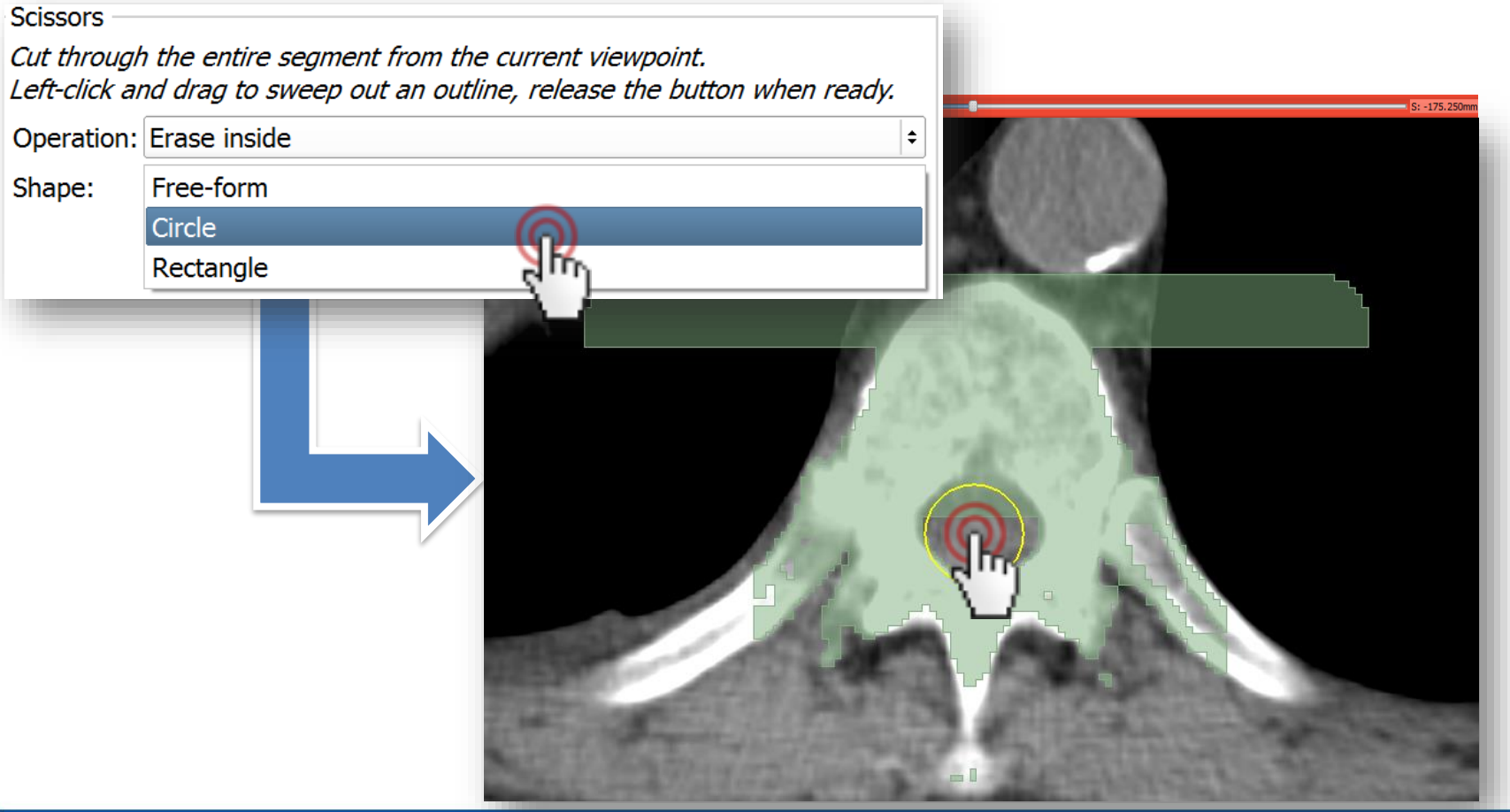
Back to Segment Editor



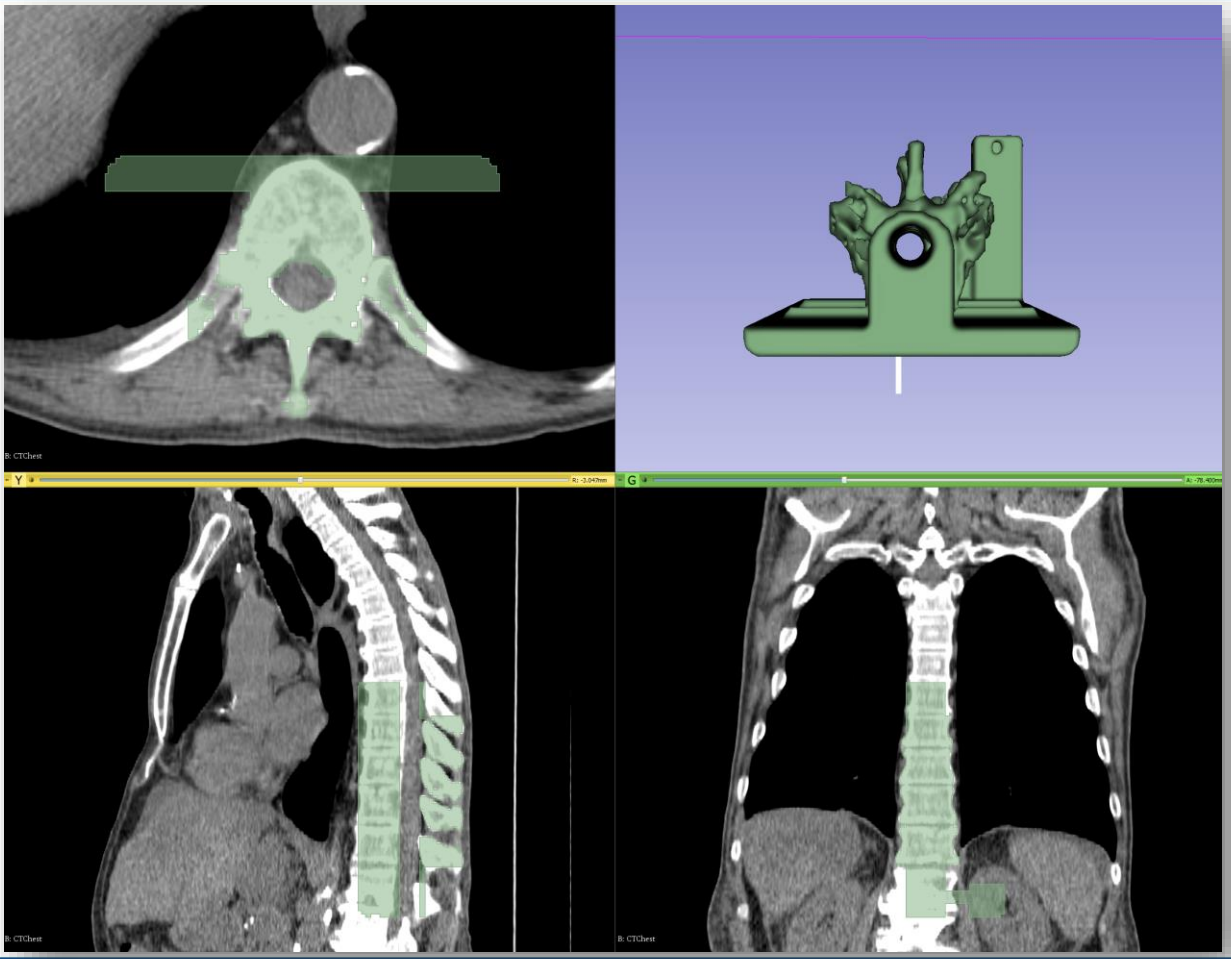
4/5: Remove base piece segment



4/6: Cut hole through phantom using Scissors



4/7: Phantom is ready



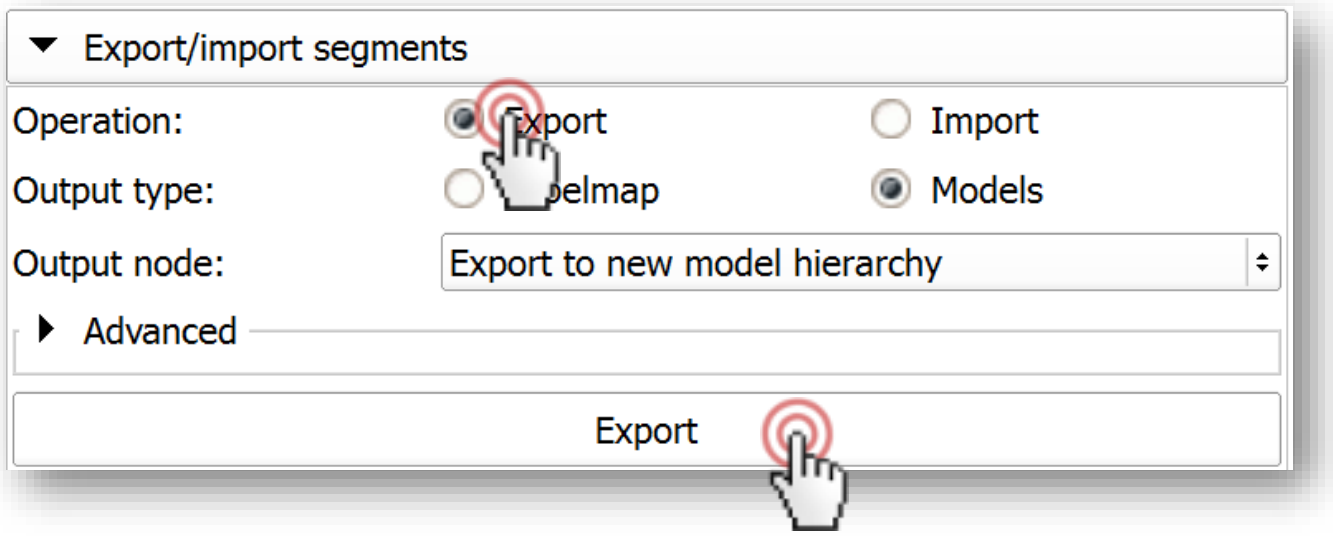
Part 5: Save phantom to STL

Overview:

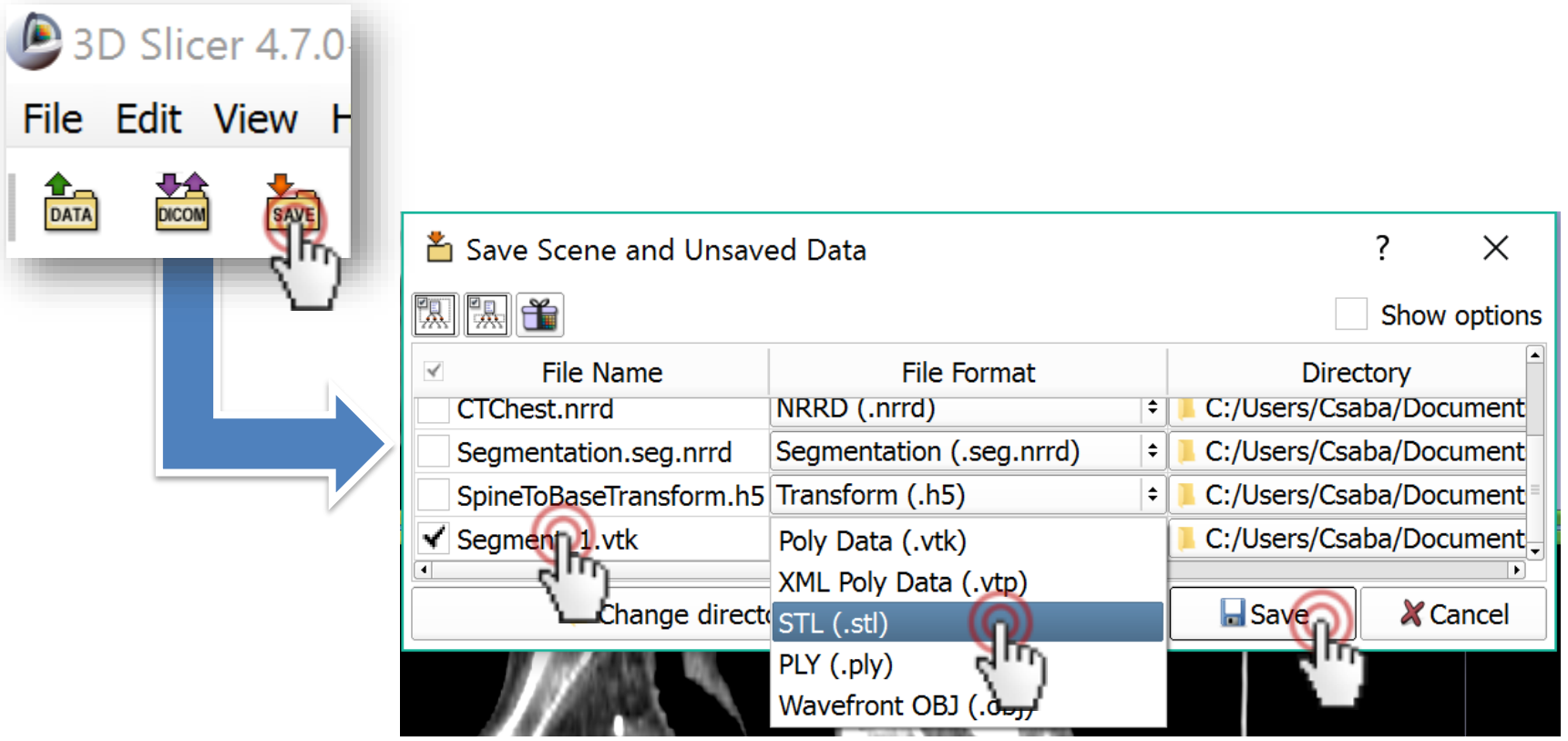
- Export phantom segment to model node
- Save model to STL file

5/1: Export phantom segment into model

Switch to Segmentations module



5/2: Save model into STL



Conclusion

Segmentation and conversion to surface is now easier with the new Segment Editor and Segmentations modules.

Acknowledgments

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