MAYO CLINIC

4DCT Processing in SlicerAutoscoper^{M}

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SlicerAutoscoper^{M} Workshop - ASB 2025
Pittsburgh, PA | August 13, 2025

Outline

- 4DCT overview
- Data upload
- Segmentation
  - Automatic Segmentation
- Creating models
- Registration – Hierarchical3DRegistration
- Saving registration

4DCT Overview

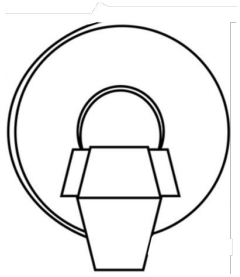
- Traditional radiographs: **overlapping anatomy; difficult to assess subtle joint abnormalities**
- Three-dimensional imaging modalities (CT, MRI): **single time point**; viewed as **serial 2D images**
- Dynamic instability challenges: may appear **"normal"** on traditional imaging

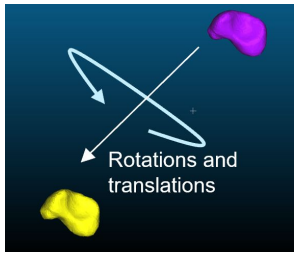
Why 4DCT?

- Certain instabilities and impingements only appear during motion demonstrating a need for dynamic imaging
- 4DCT (3DCT over time) offers the opportunity to visualize bones during motion
  - *Osteokinematics* (bone motion) can be used to quantify bone biomechanics (or arthrokinematics) during motions and functional tasks

4DCT Overview

Data acquisition → Radiographs → DICOM format → Export → Segmentation → Registration





Processing 4DCT

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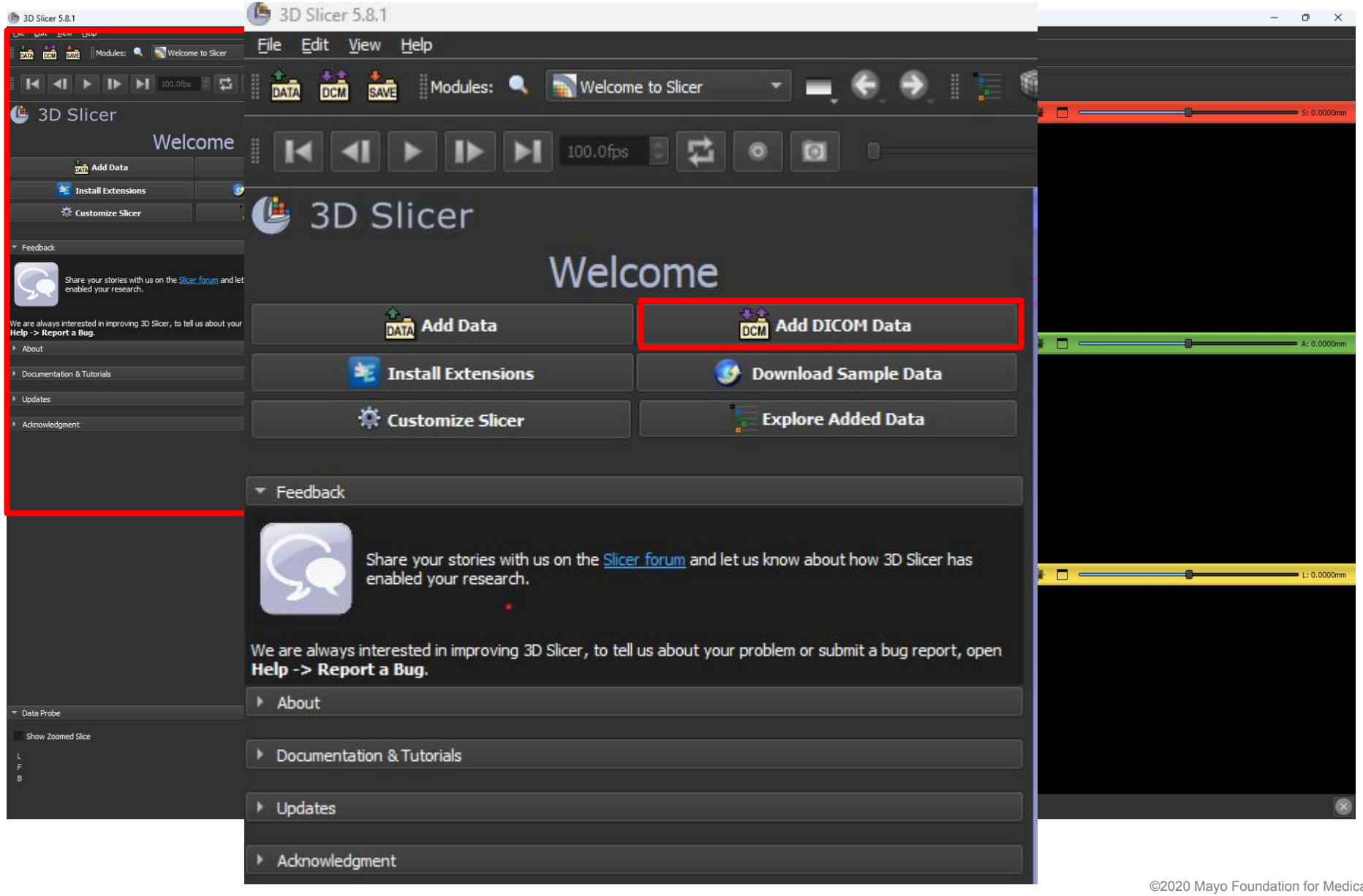
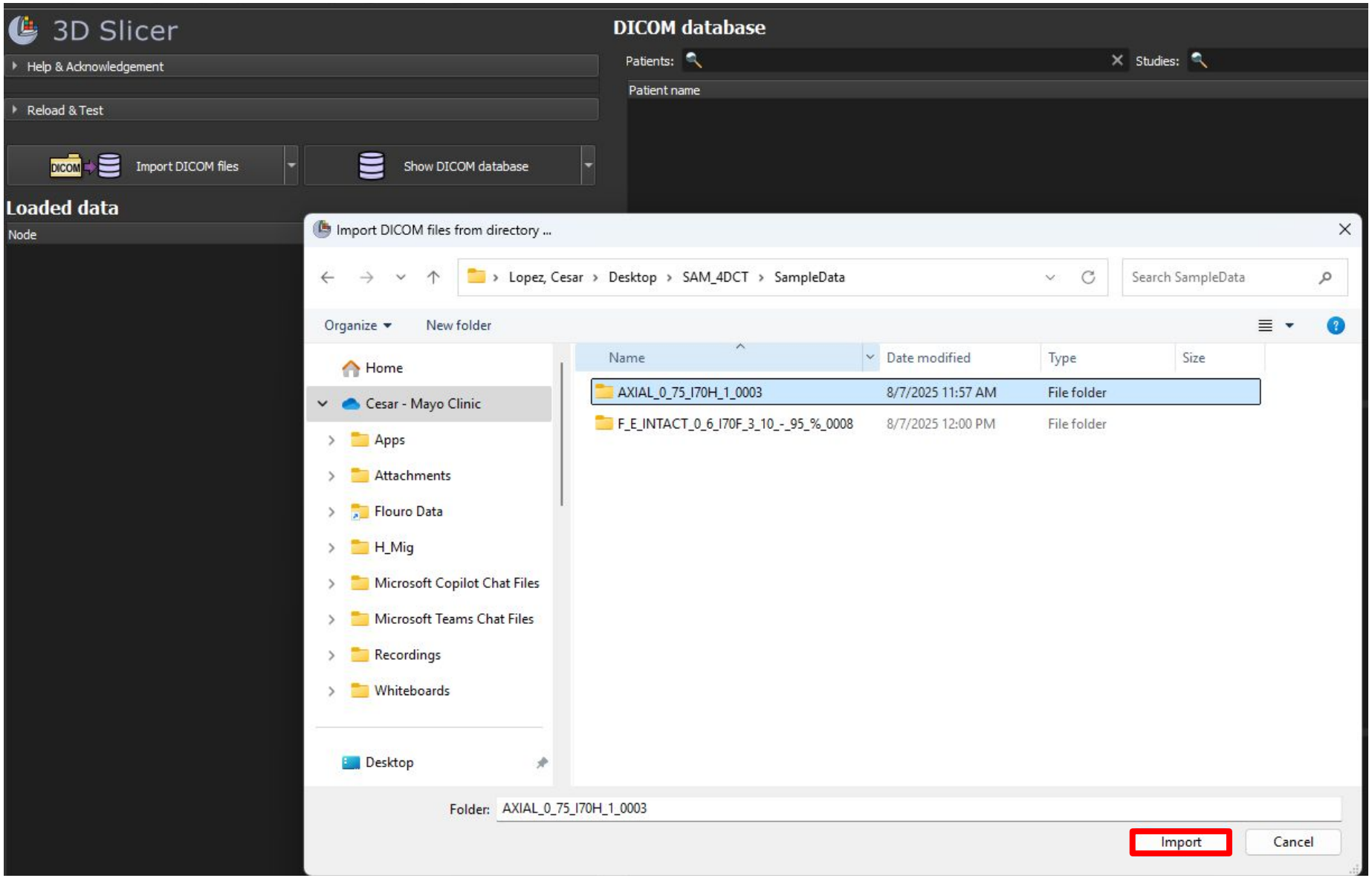
4DCT Data upload



4DCT Data upload



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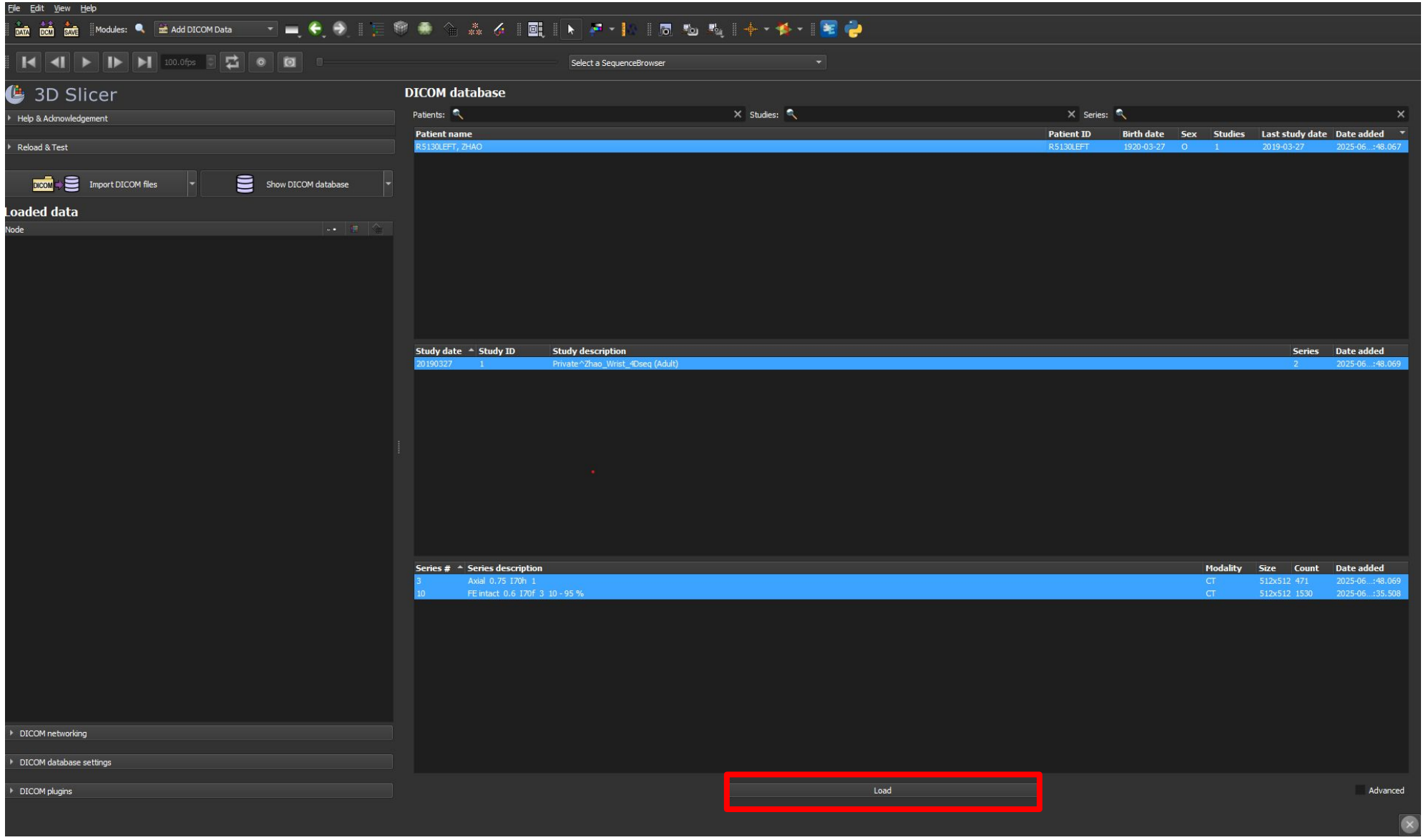

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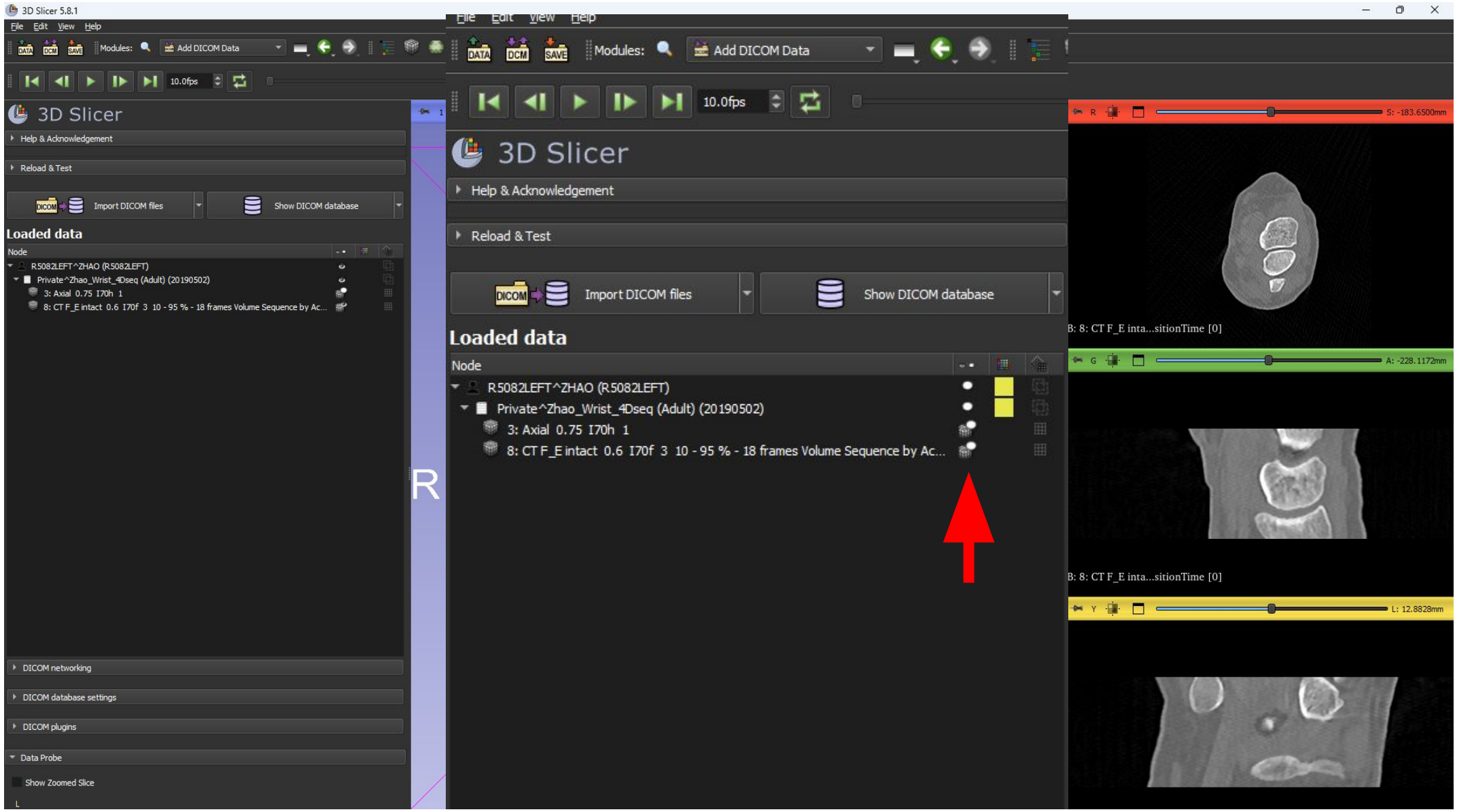
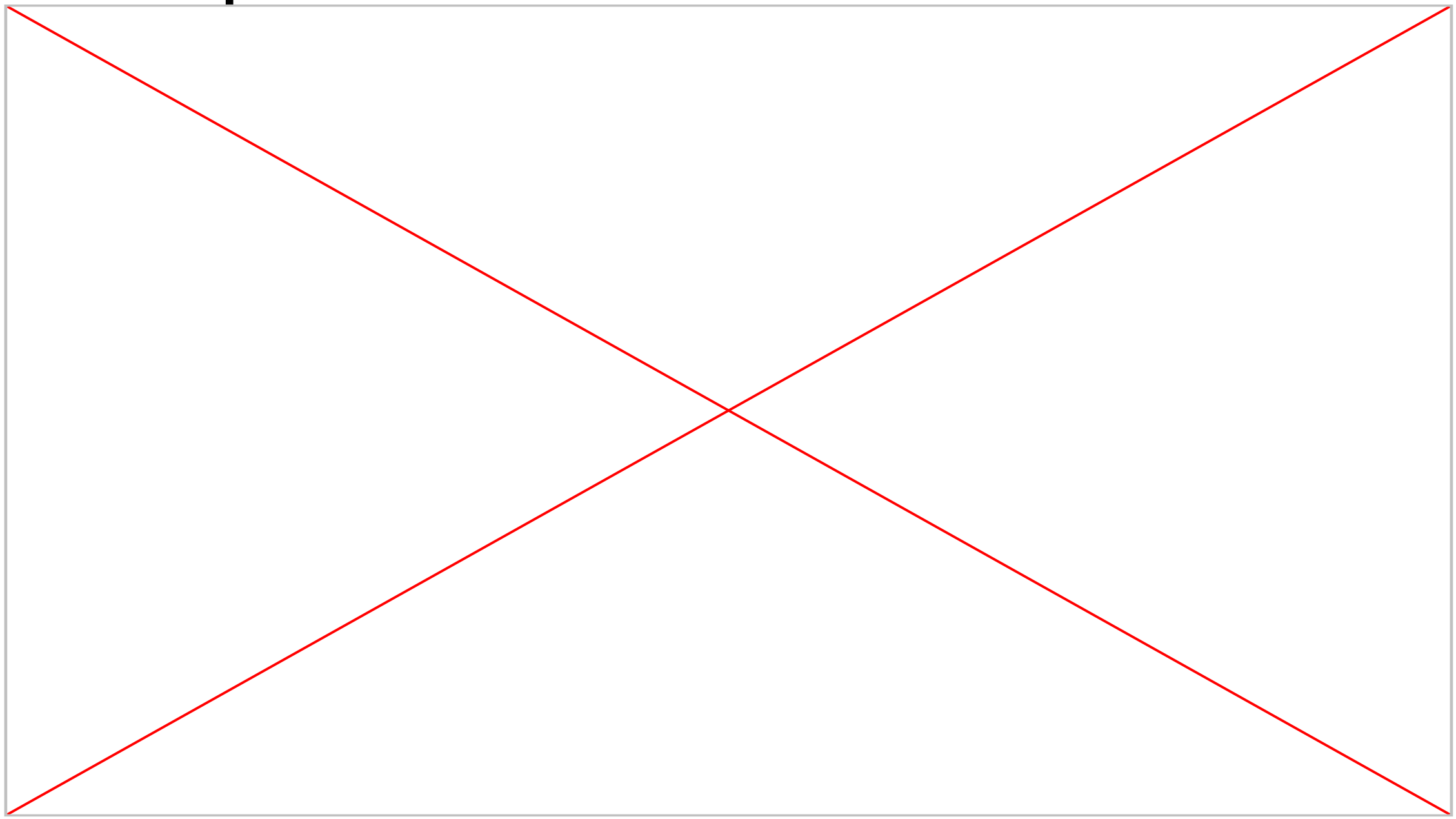
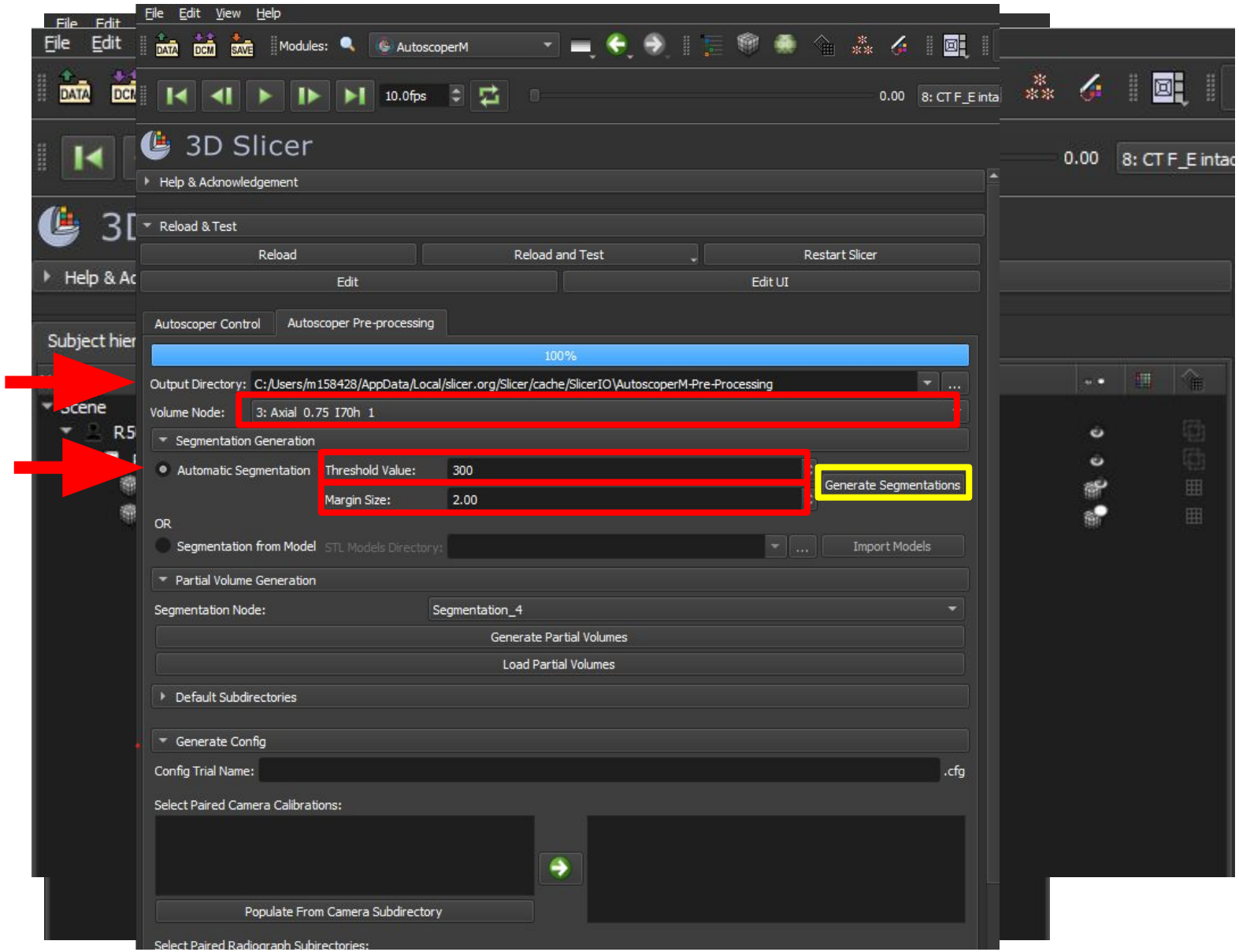


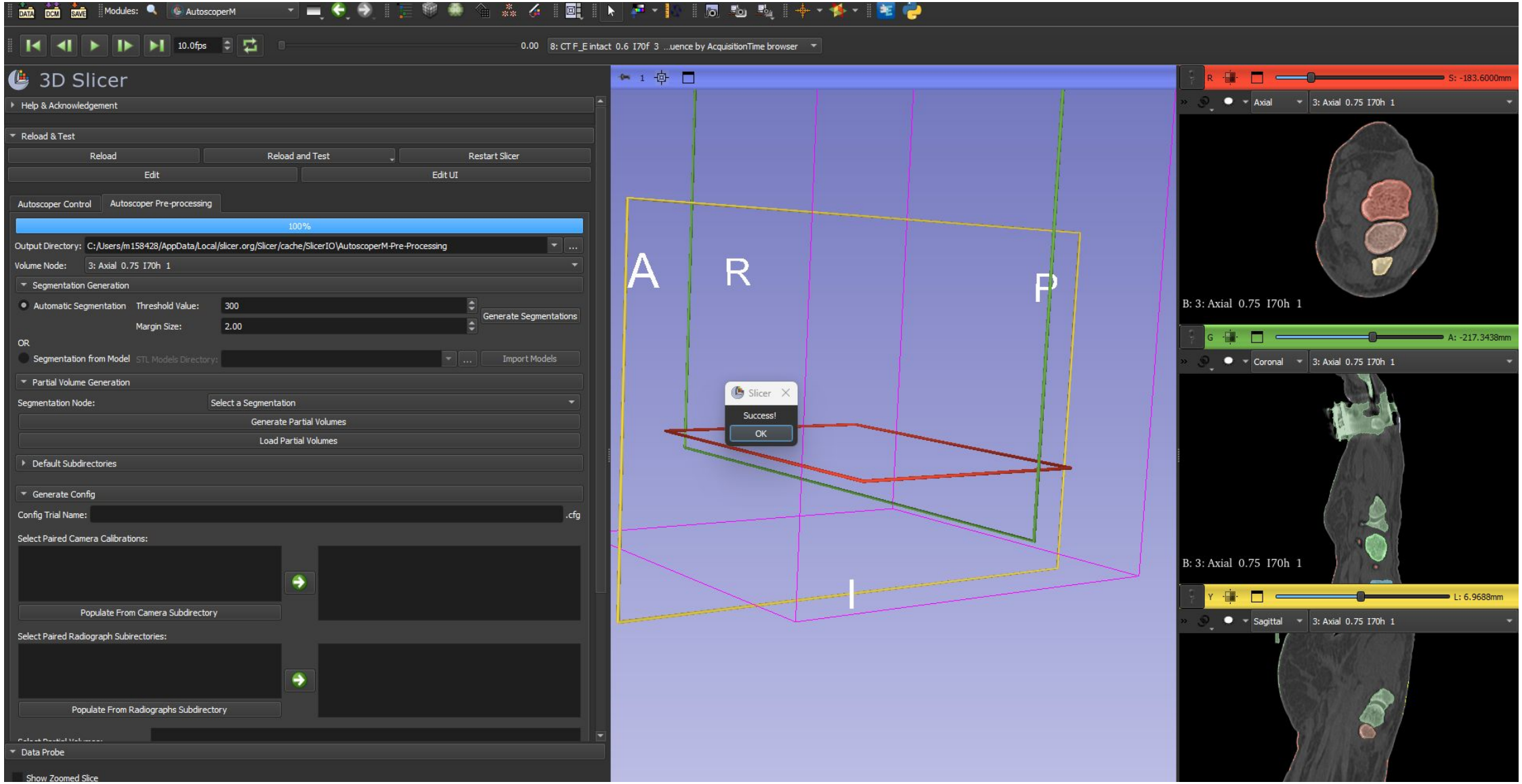
4DCT Data upload



Segmentation - AutoscoperM



Segmentation - Autoscoper^{M}



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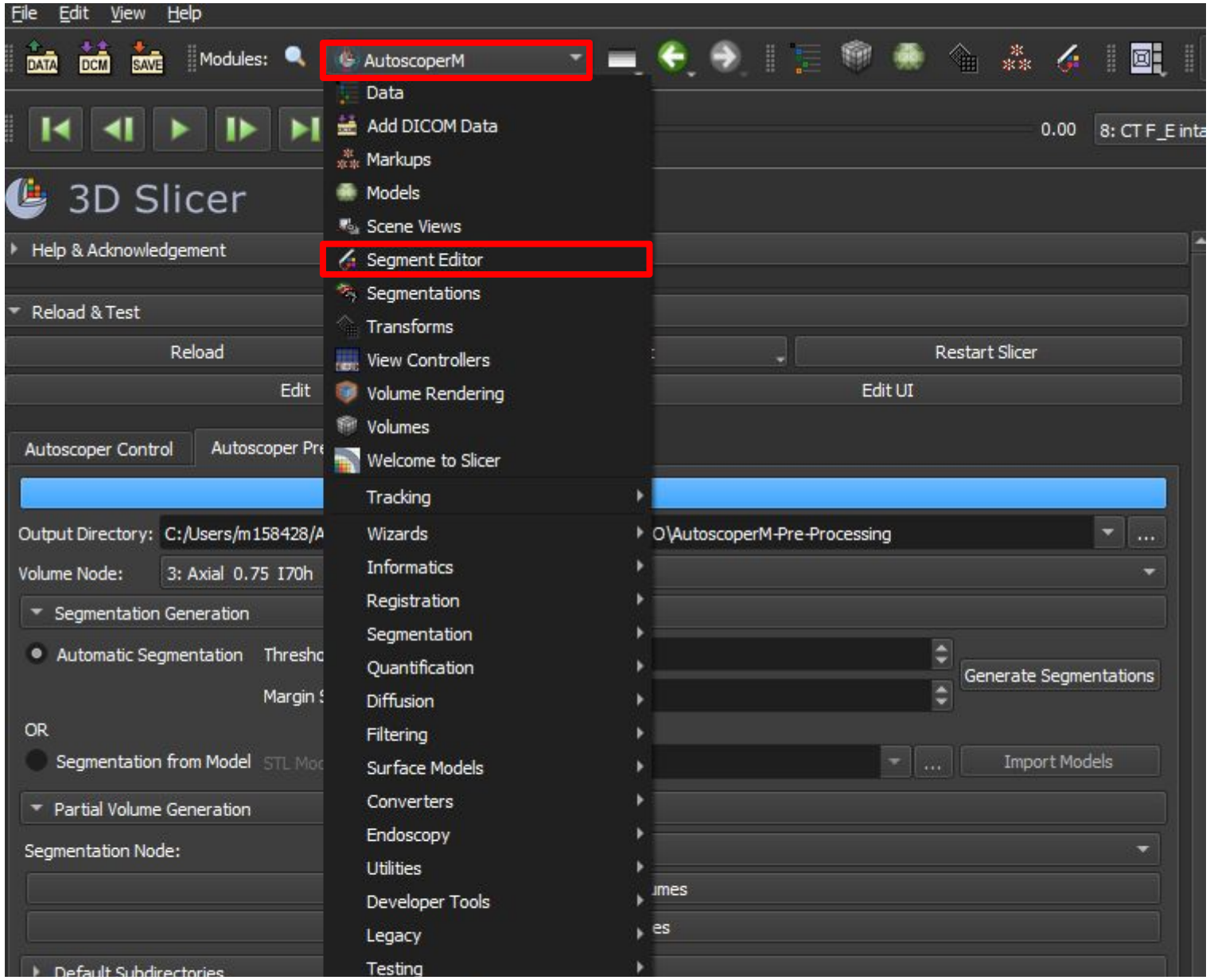

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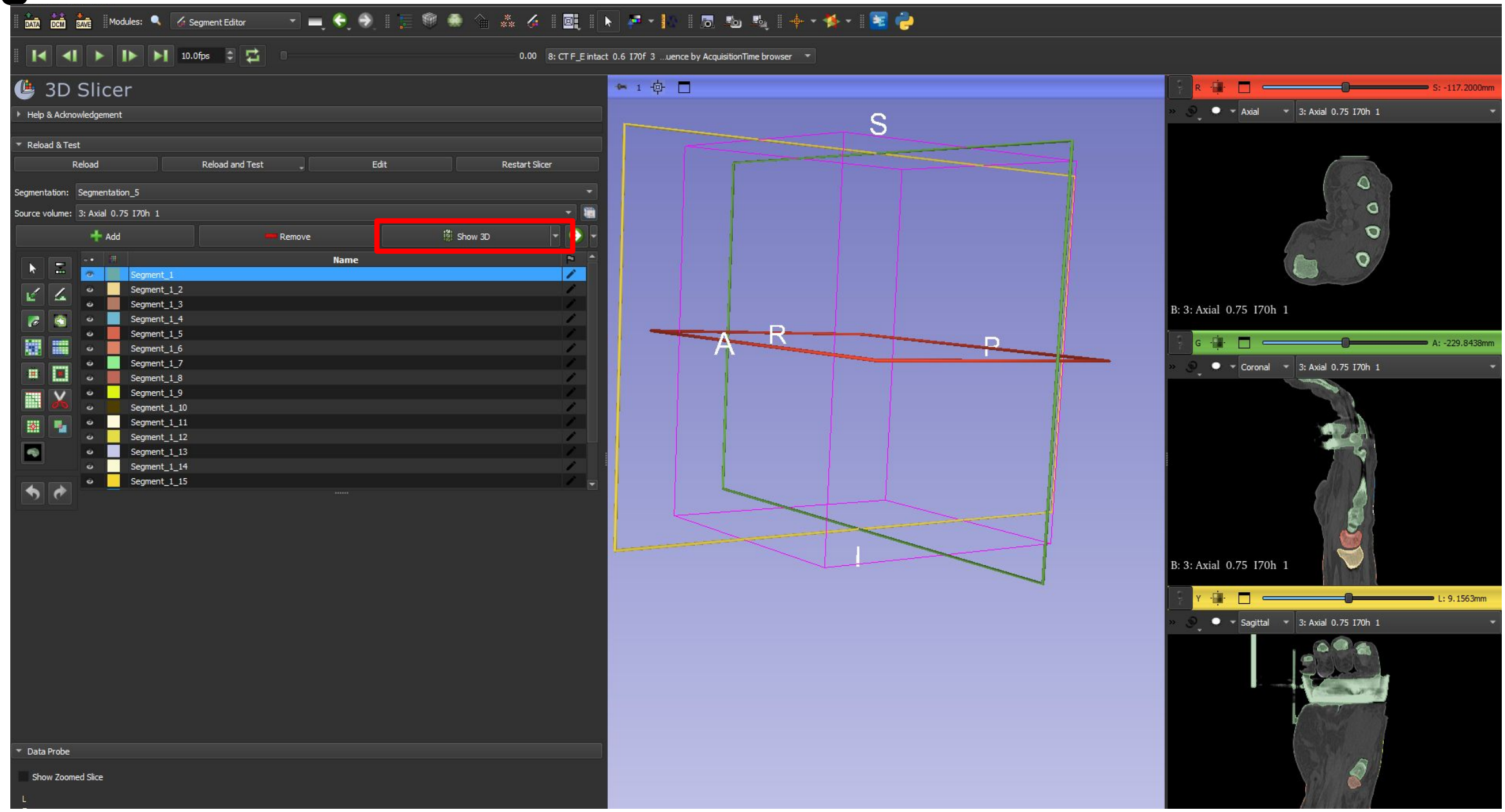

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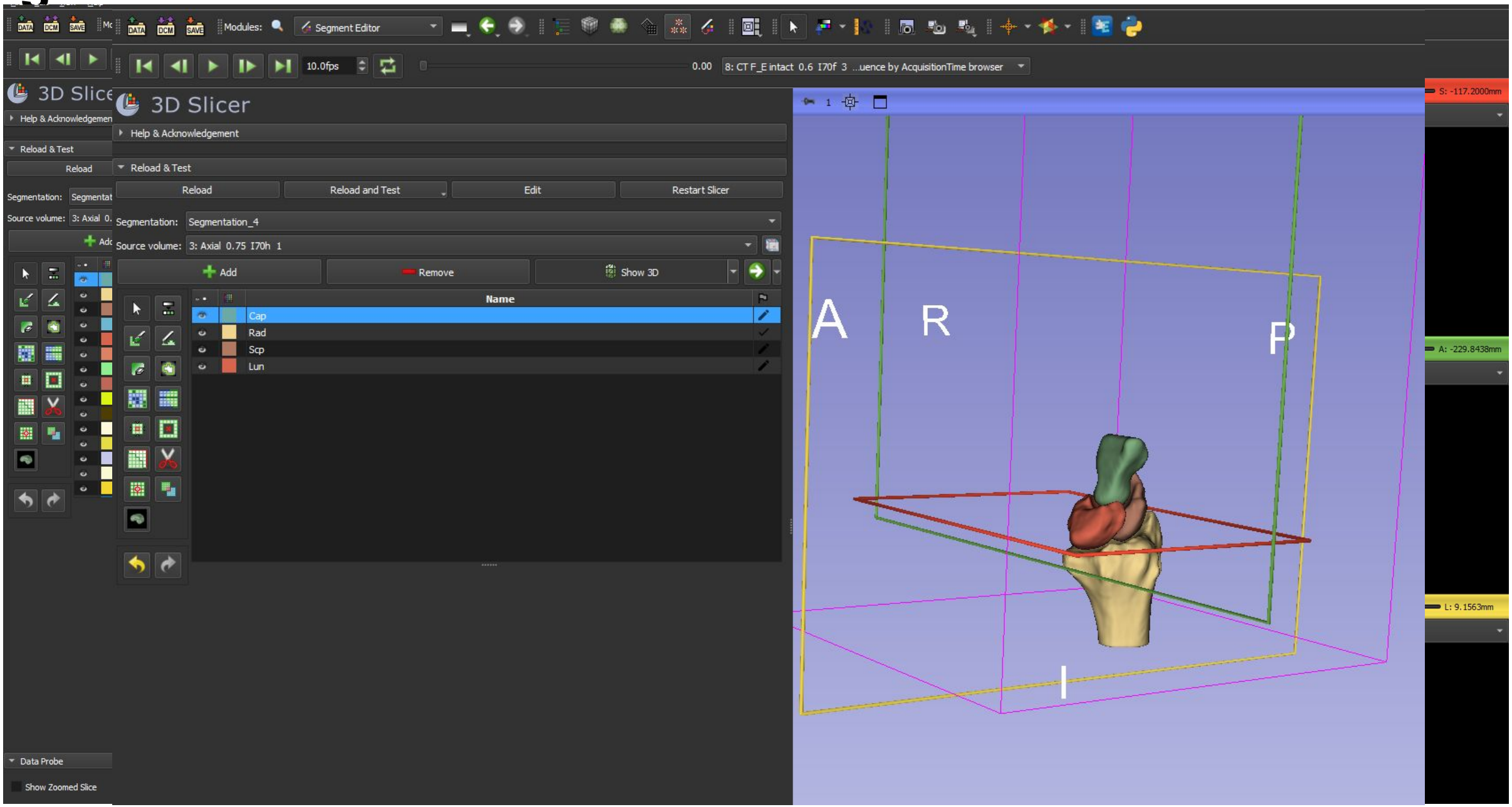
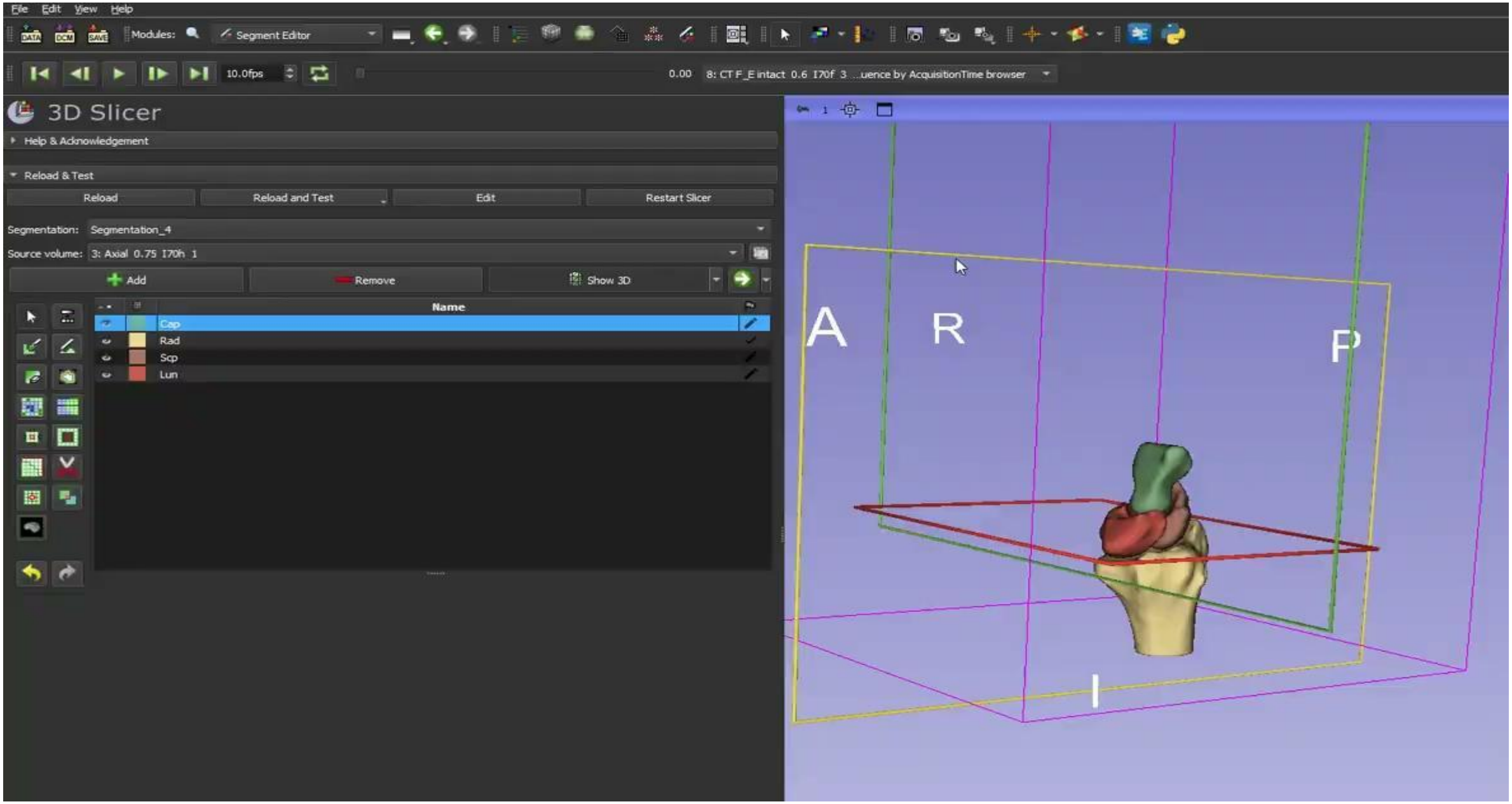
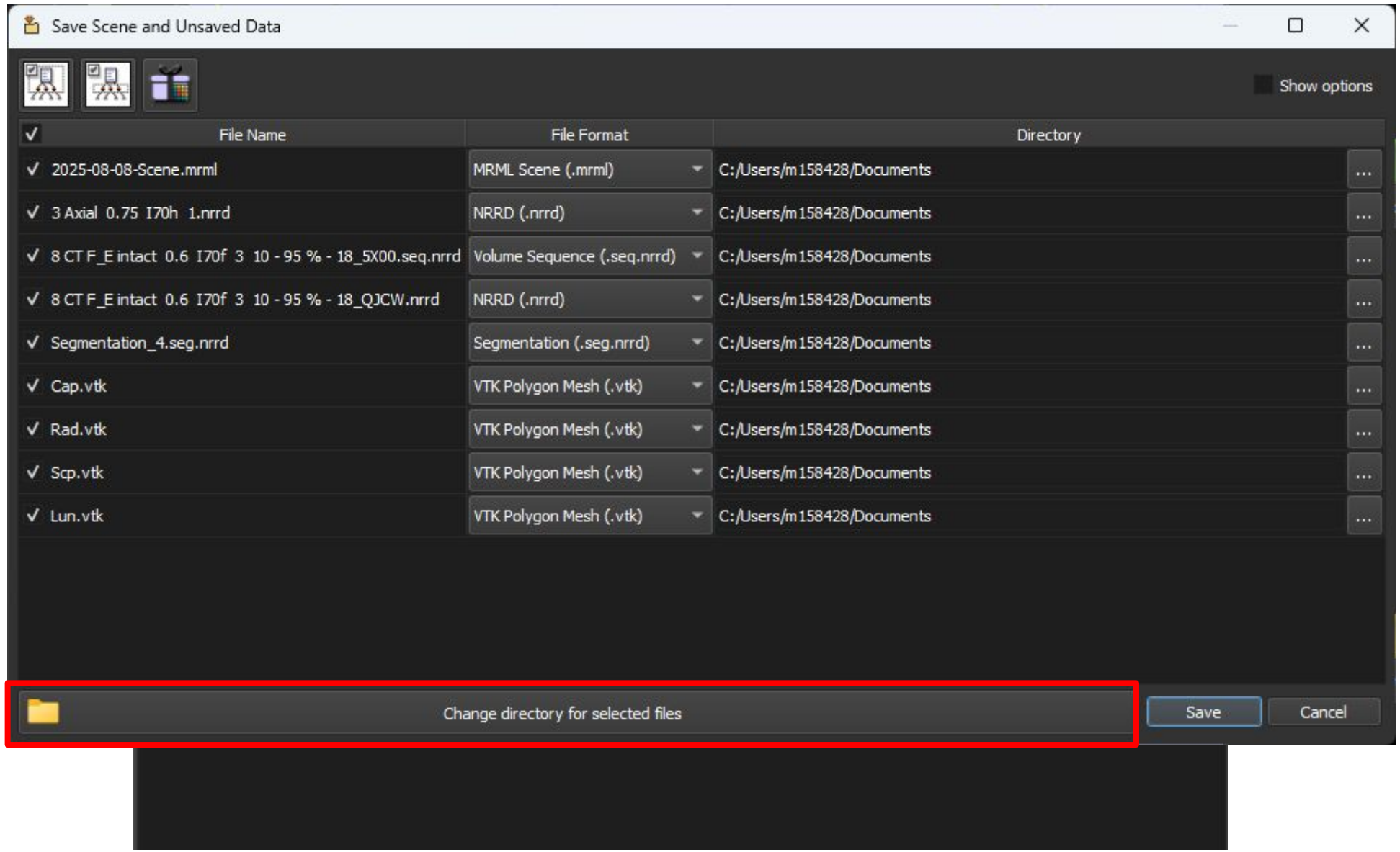


Model Creation



Saving NRRD, Volume Sequence, Model



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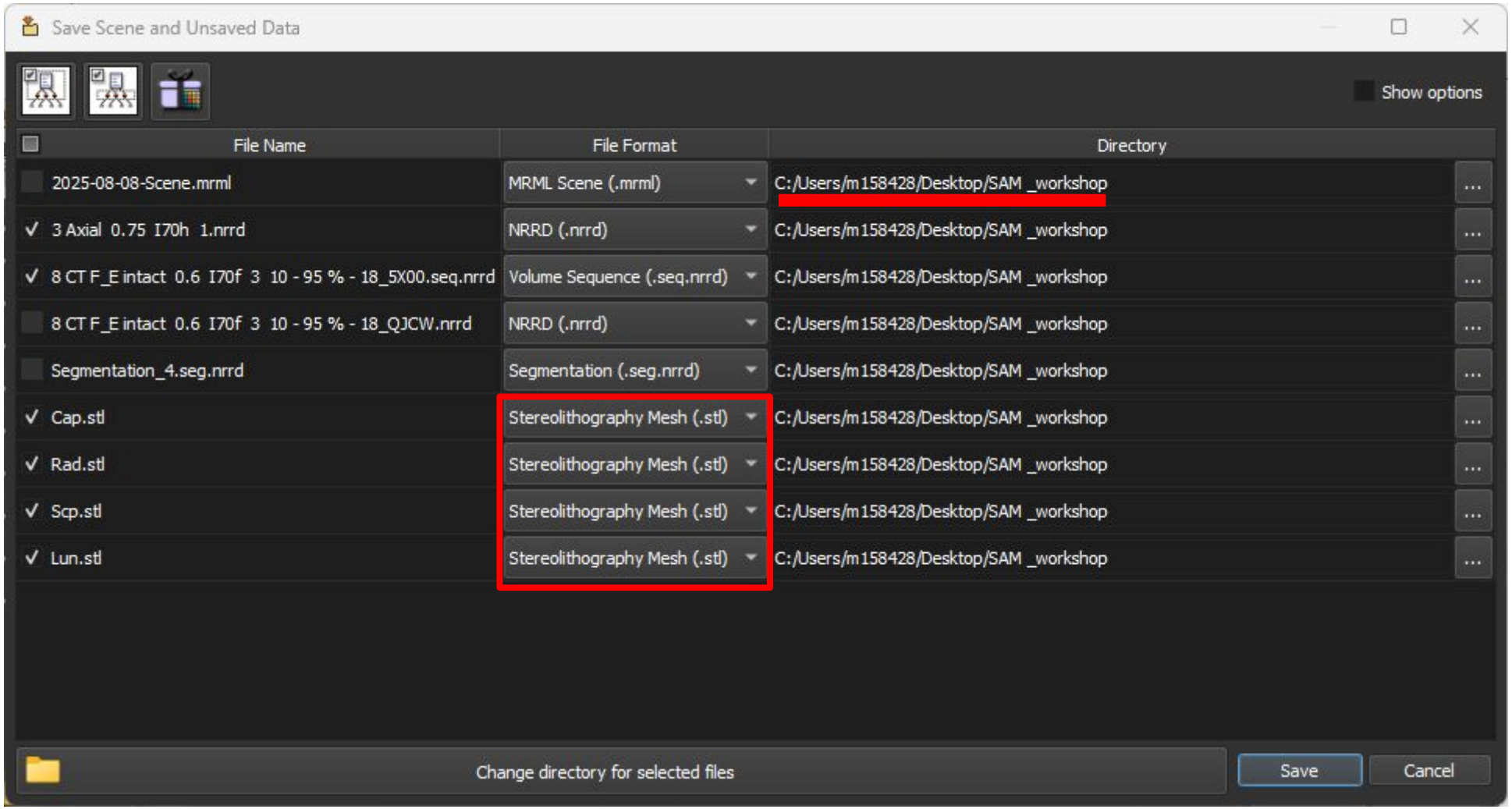

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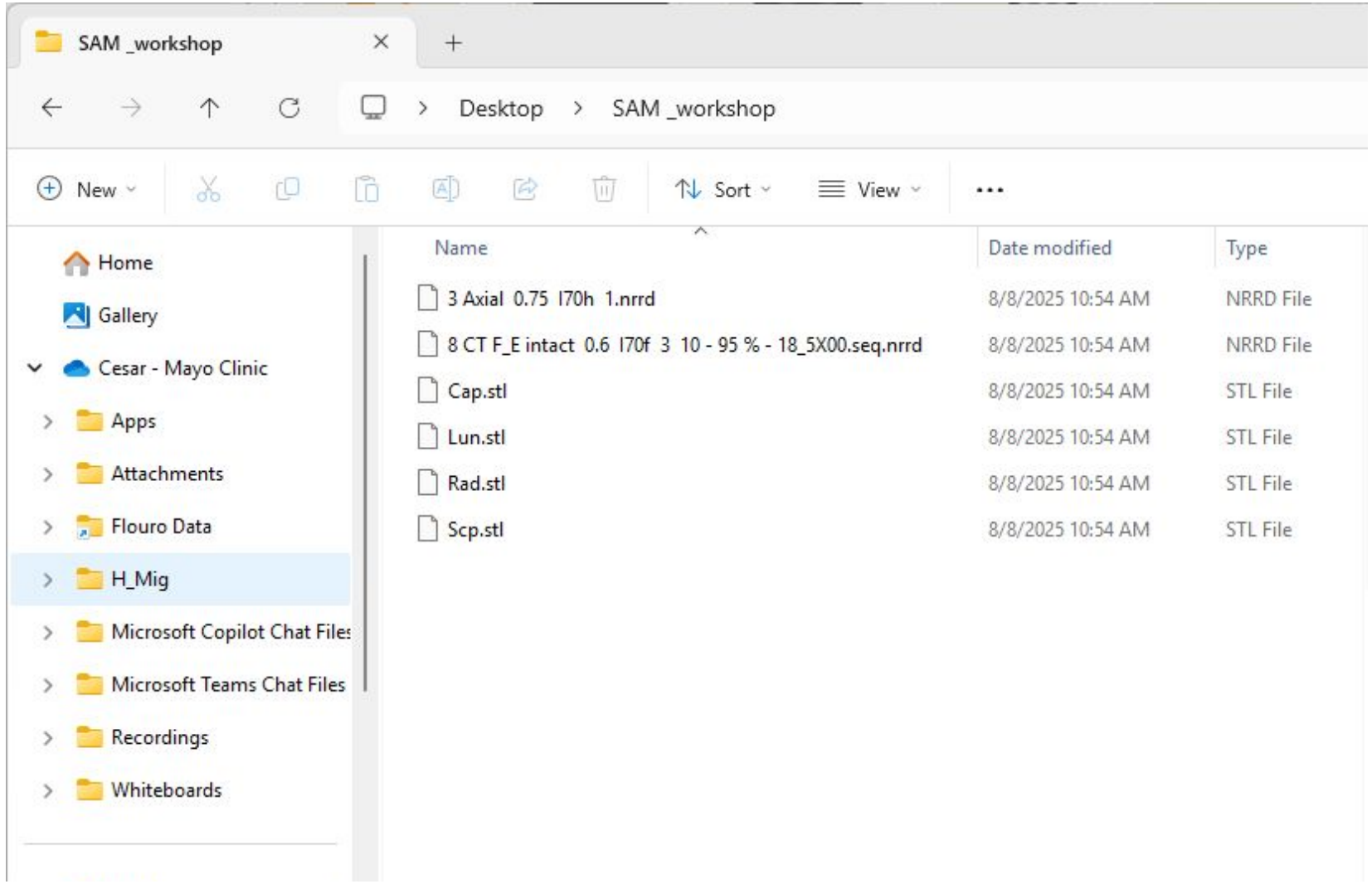

Hierarchical3DRegistration

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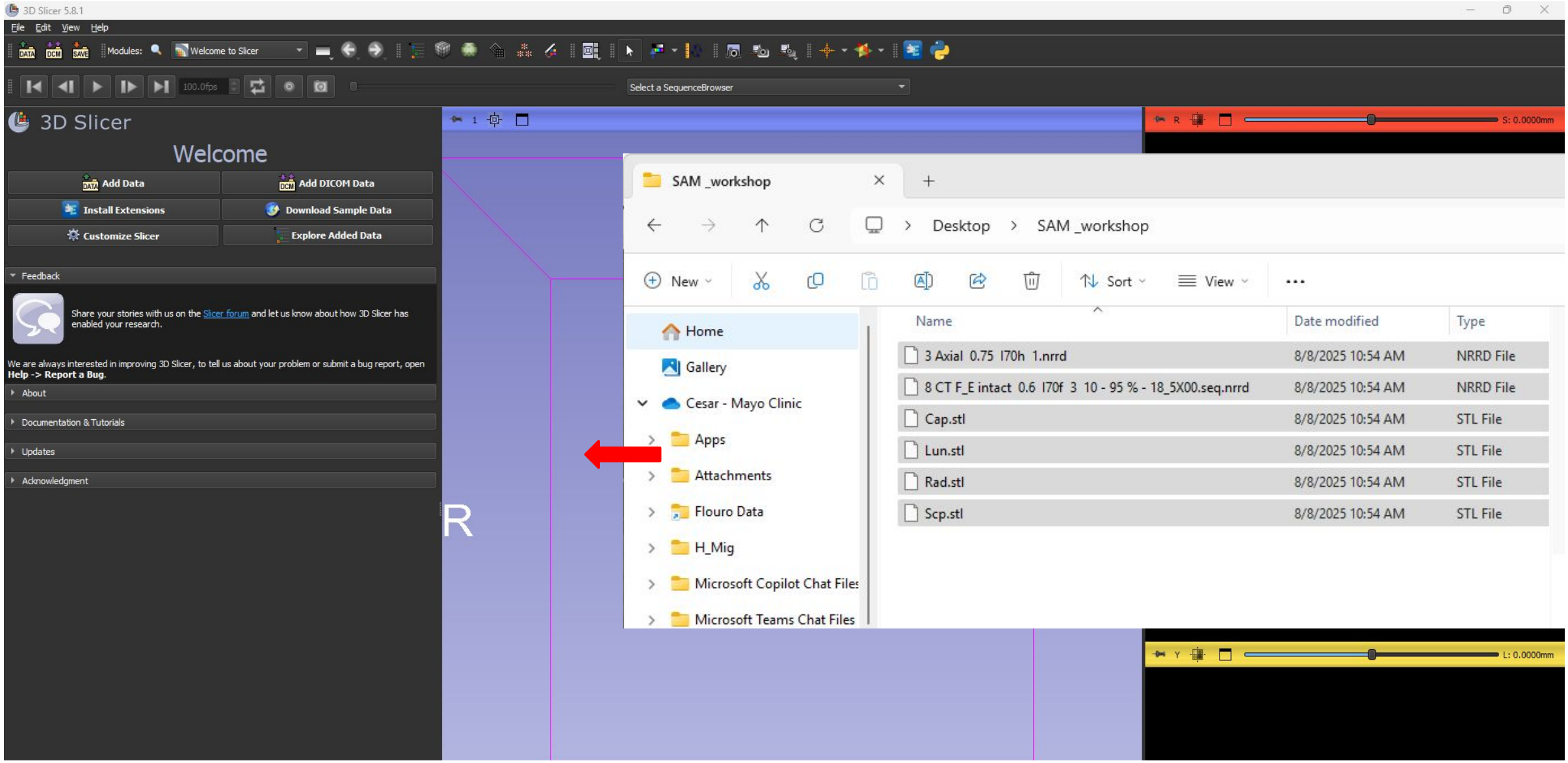
Hierarchical3DRegistration



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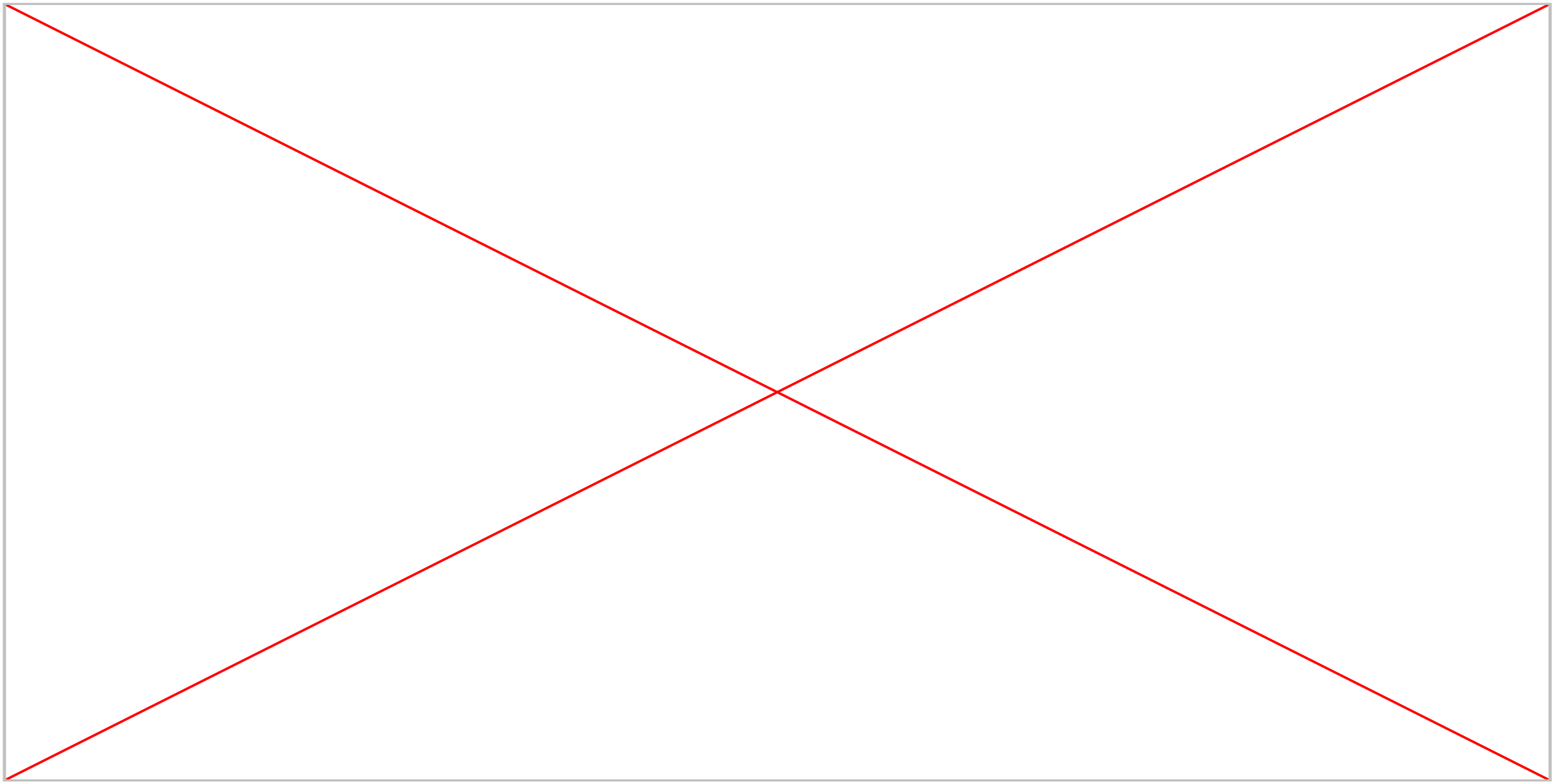

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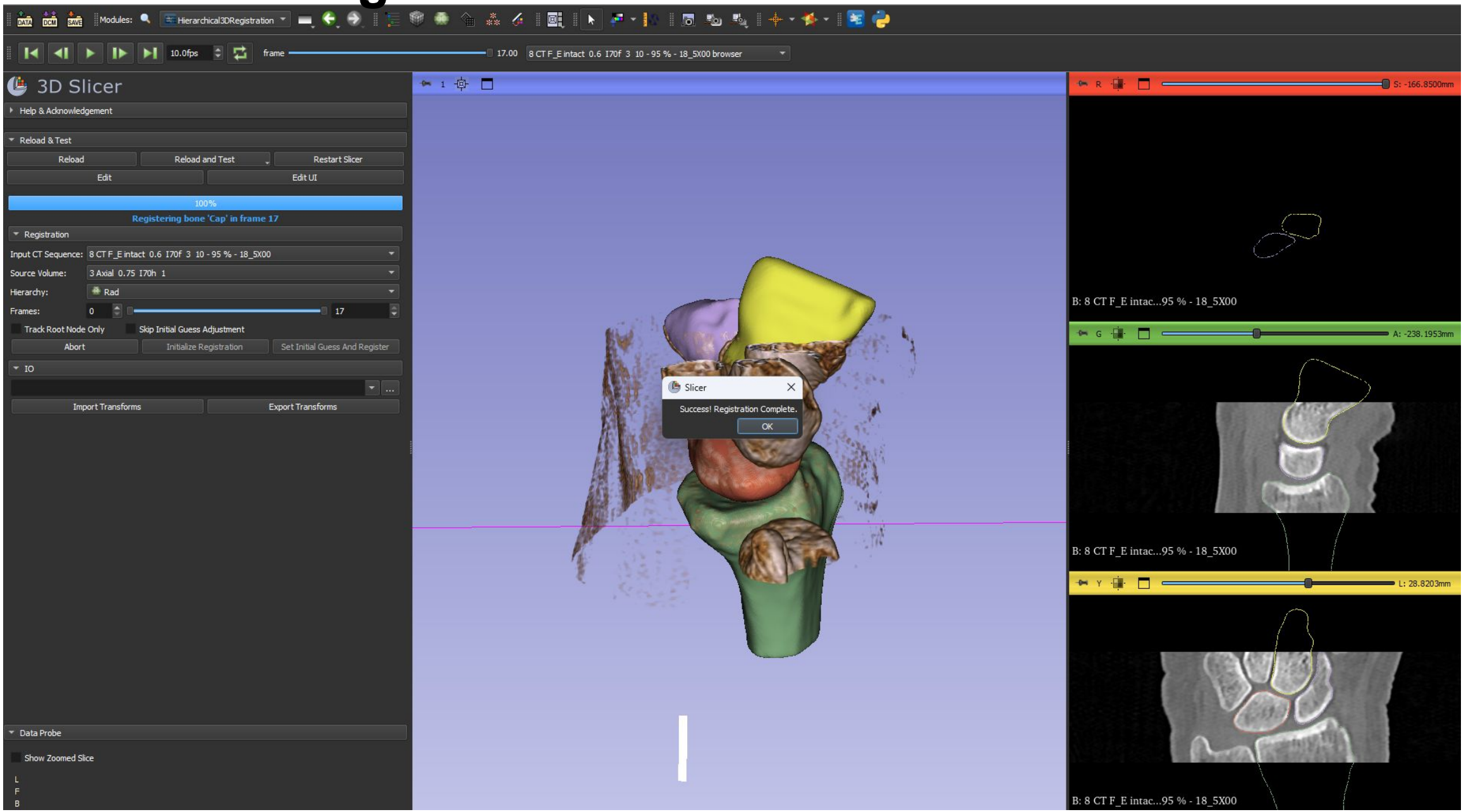
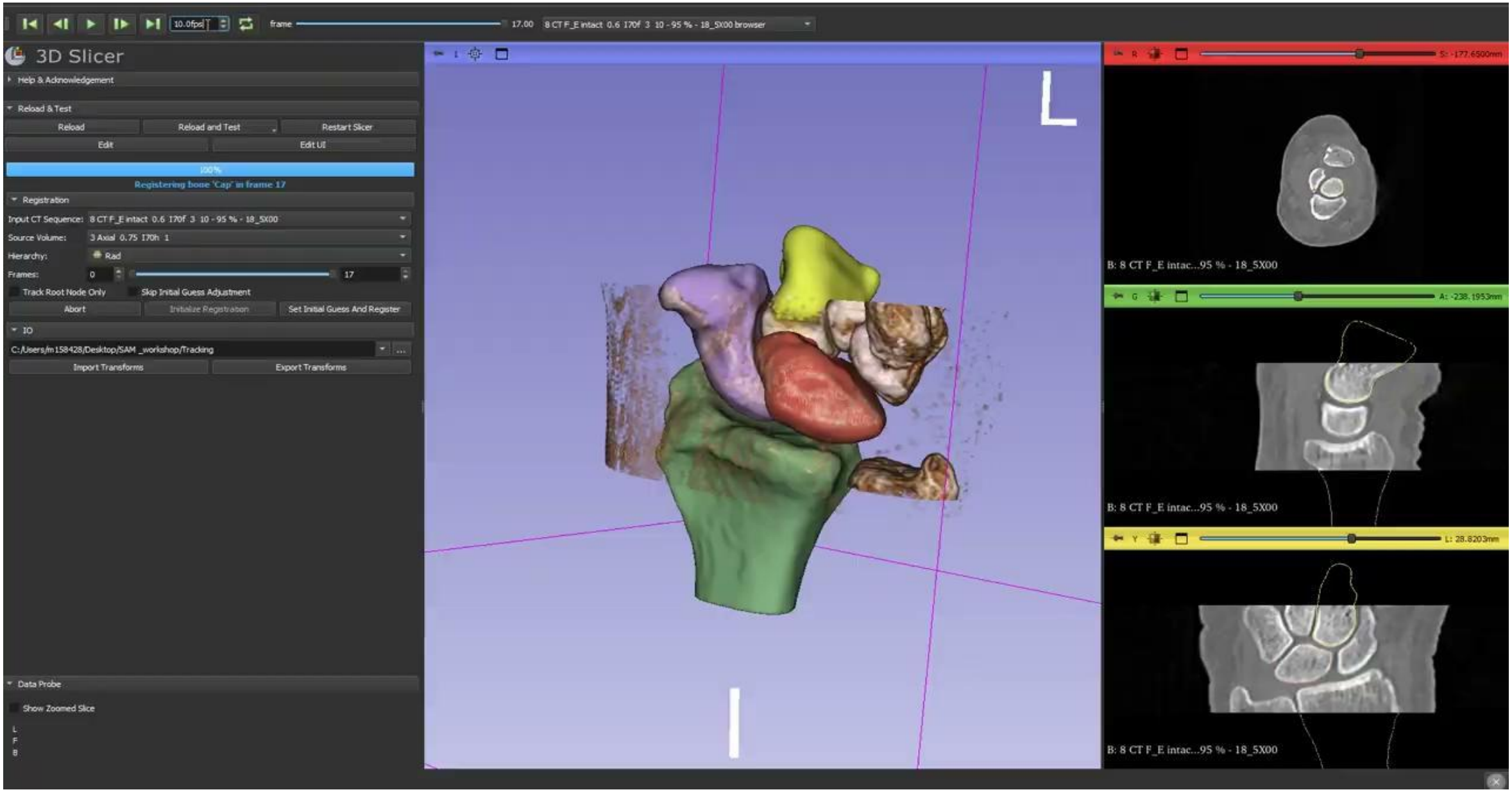
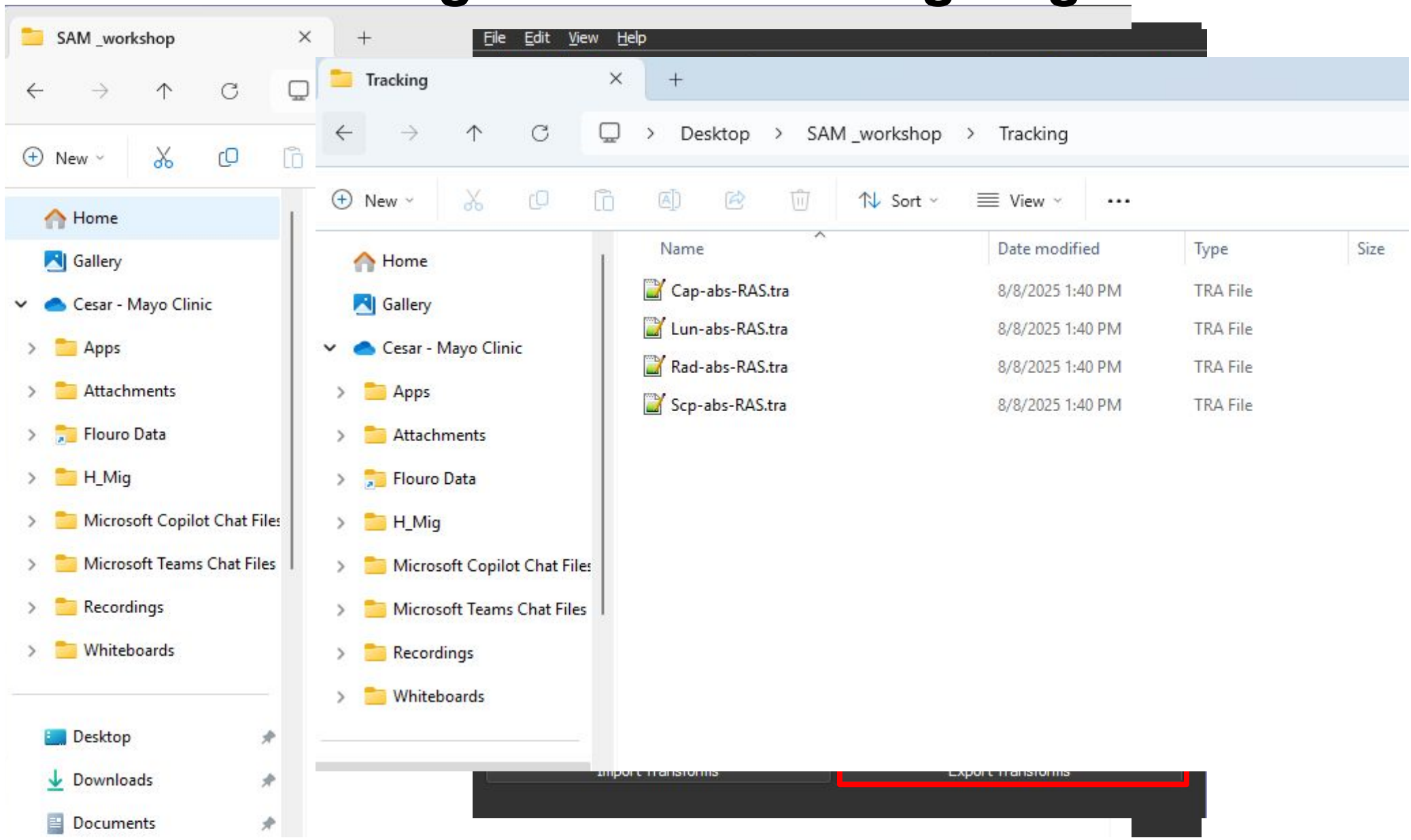


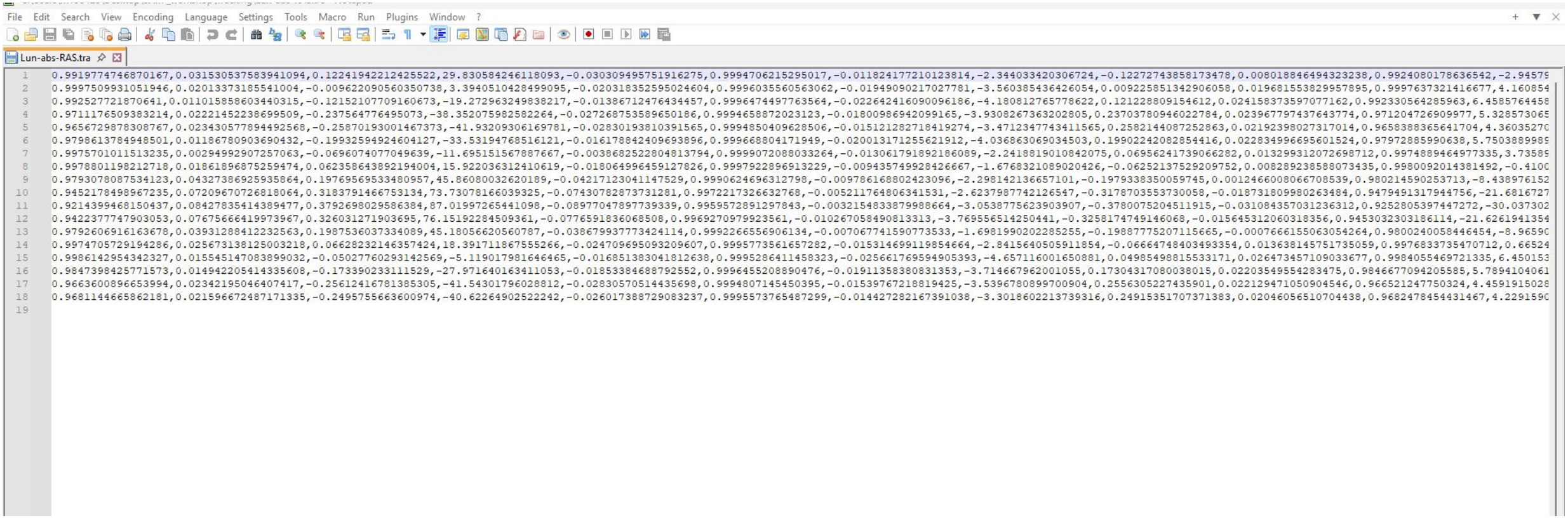
Hierarchical3DRegistration



Hierarchical3DRegistration – Saving Registration



Hierarchical3DRegistration – Tracking file



SlicerAutoscoper™

- **Community-driven**
- **Integration of BVR, 3DCT and 4DCT workflows into a single platform**
- **Standardization across institutions**
- **Promotes transparency and collaboration**
- **Faster learning curve: Improved accessibility for trainees and non-engineers**
- **Partial volumes? NOT A PROBLEM!!!!**

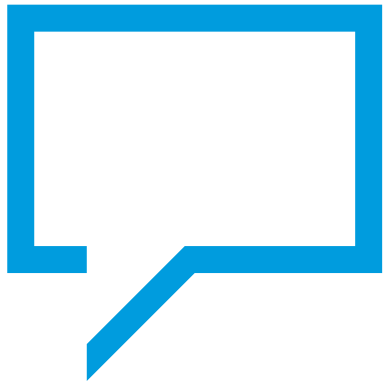
*Greater alignment in software capabilities may facilitate post-processing approaches
*Software alignment may **expedite translation to the clinic**

Acknowledgments

National Institute of Arthritis and Musculoskeletal and Skin Diseases

R01 AR071338
R01 AR078924

THANK YOU



Extra

Image acquisition

- A third-generation, dual-source CT scanner (SOMATOM Definition Force, Siemens Healthcare) is used to acquire neutral-static and dynamic CT scans

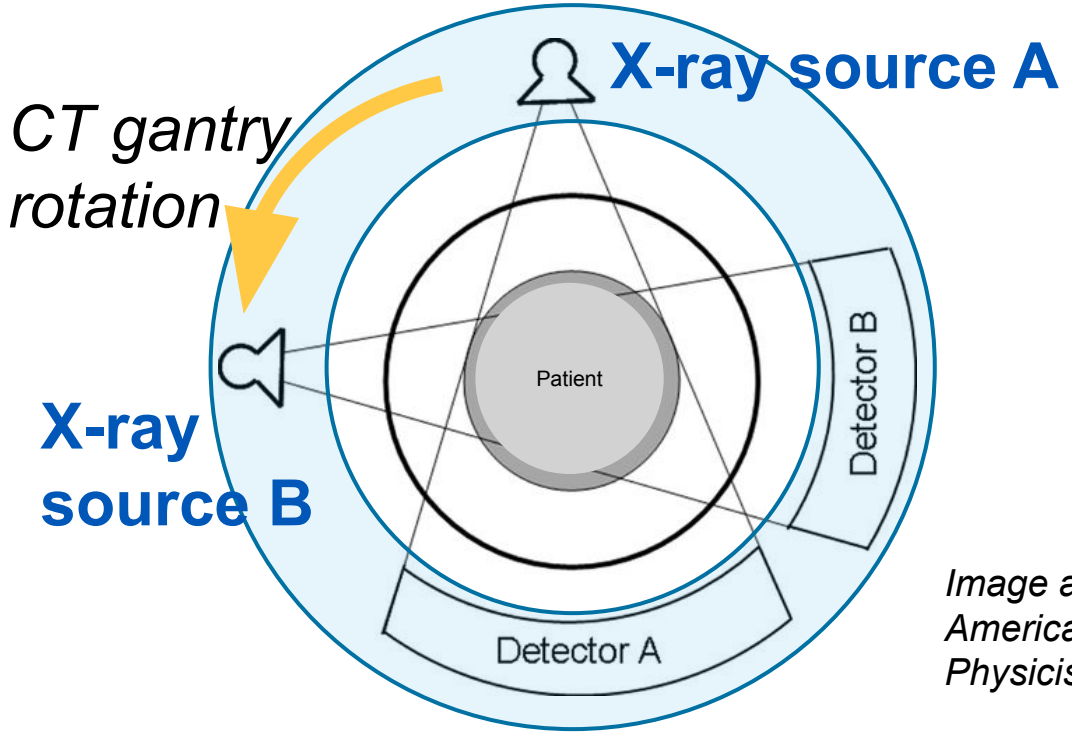
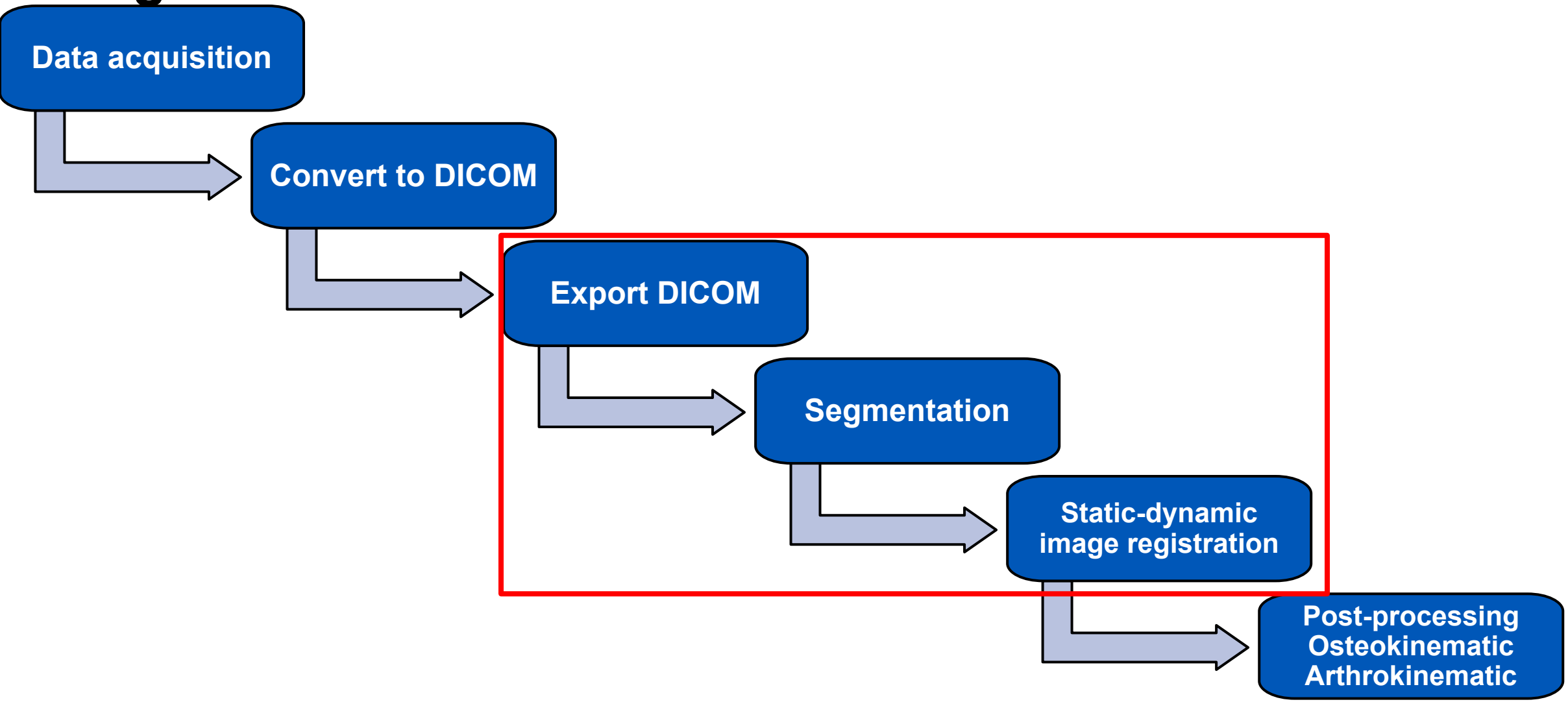


Image adapted from the American Association of Physicists in Medicine

Temporal resolution: 66 ms

Background – 4DCT Process



Background

Image acquisition

- **Static**:
  - Bilateral static (3D) CT volumes are acquired typically in neutral position using a routine CT scan protocol (120 kV, 200 mAs/rotation, 1 second gantry rotation).

- **Dynamic**:
  - Bilateral dynamic (4D) CT volumes are acquired using sequential, dual-source cardiac protocol over a 1.5-second period
    - Data collection was triggered via EKG simulator (30 bpm)
    - Auditory and visual cues were delivered to participants with a digital metronome (70 bpm) to set the cadence such that a full motion cycle would be acquired during the scanning interval
  - This yielded 17 sequential CT volumes evenly temporally-distributed across the motion cycle

