# Dynamic management of segmented structures in 3D Slicer

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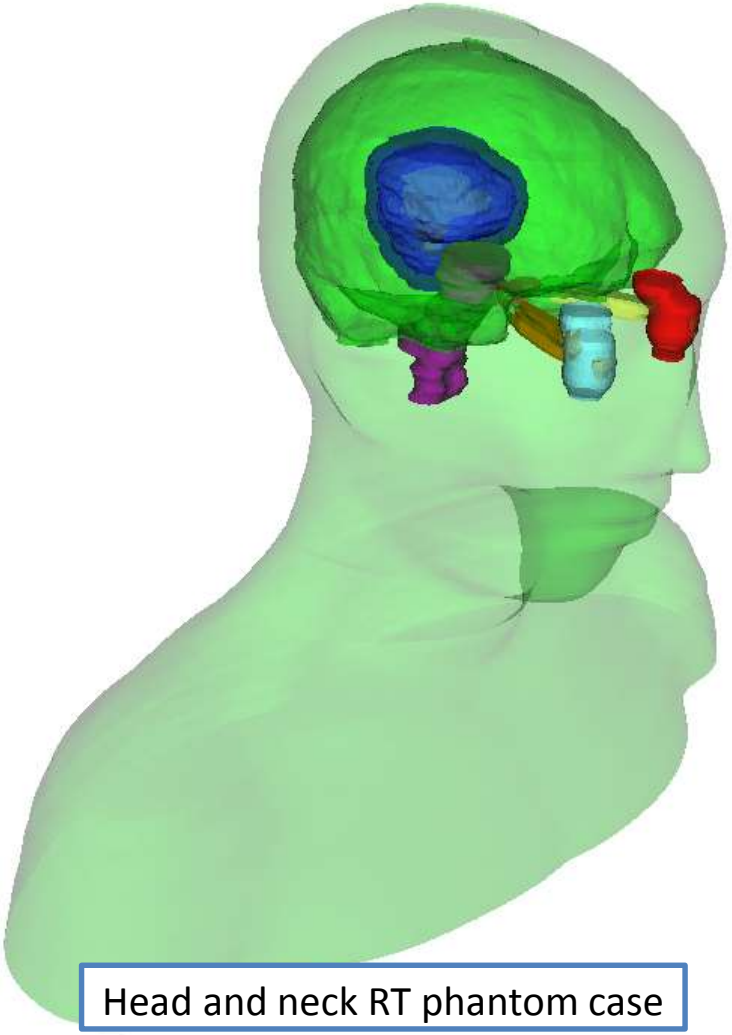
# Segmentation

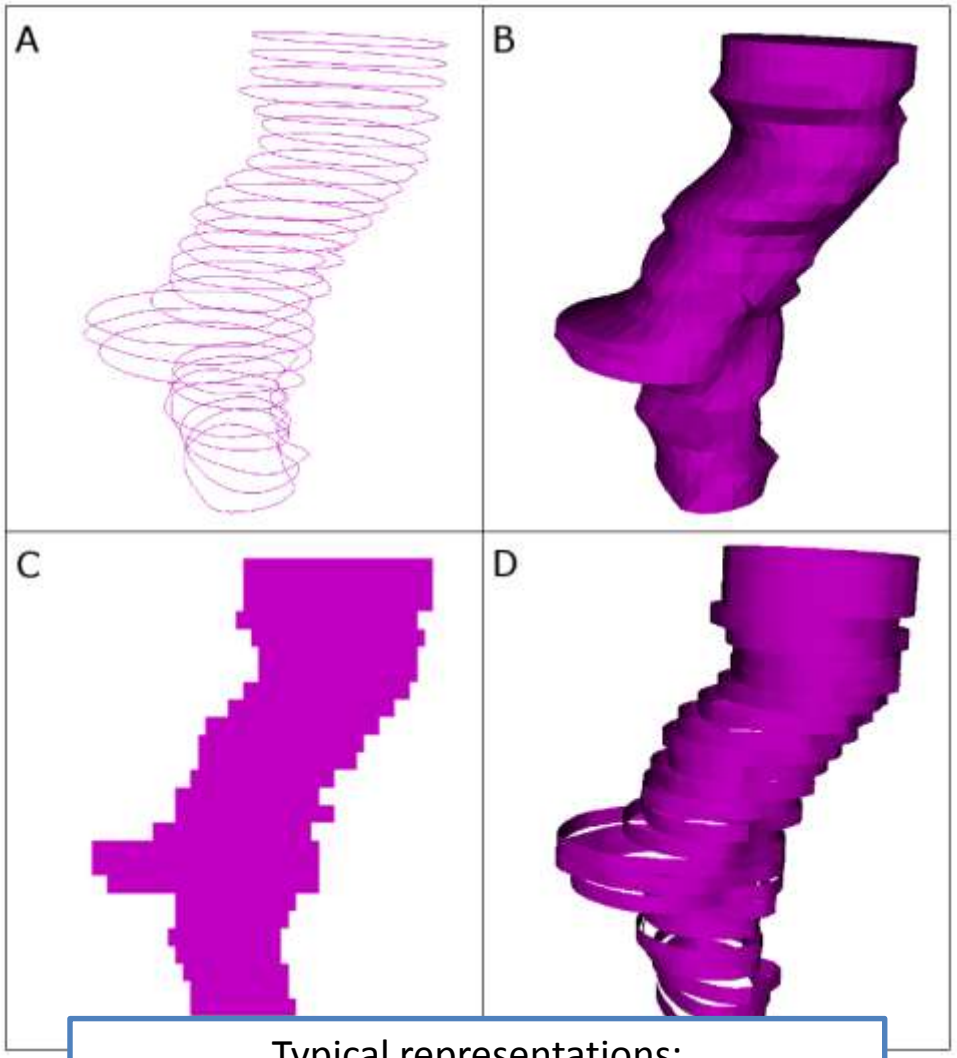


Head and neck RT phantom case

- Also known as contouring
- Delineates structures of interest
  - Manual contouring: Slice by slice
  - Automatic / semi-automatic
- Omnipresent in medical imaging
  - Surgical/radiation therapy **planning**
  - Intra-surgery **navigation**
  - Volume/shape **analysis**
  - 3D printing (**interventions**)
  - **Education**

# Various representations

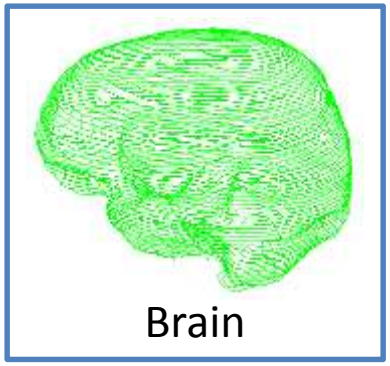
- Each optimal for
  - *either* storage (A)
  - *or* analysis (C)
  - *or* visualization (B,D)
- Imposed needs
  - Conversion
  - Simultaneous
    - Visualization
    - Transformation




Typical representations:
A: Contours, B: Surface, C: Image, D: Ribbons

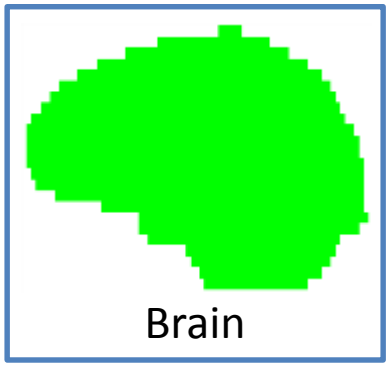
# Difficulty #1: Operation

- Operation
  - User needs to be aware of the need for conversion, and also
  - How to perform it




Analysis ?

- Volume
- Surface area
- Dose volume histogram
- Dice coefficient
- …

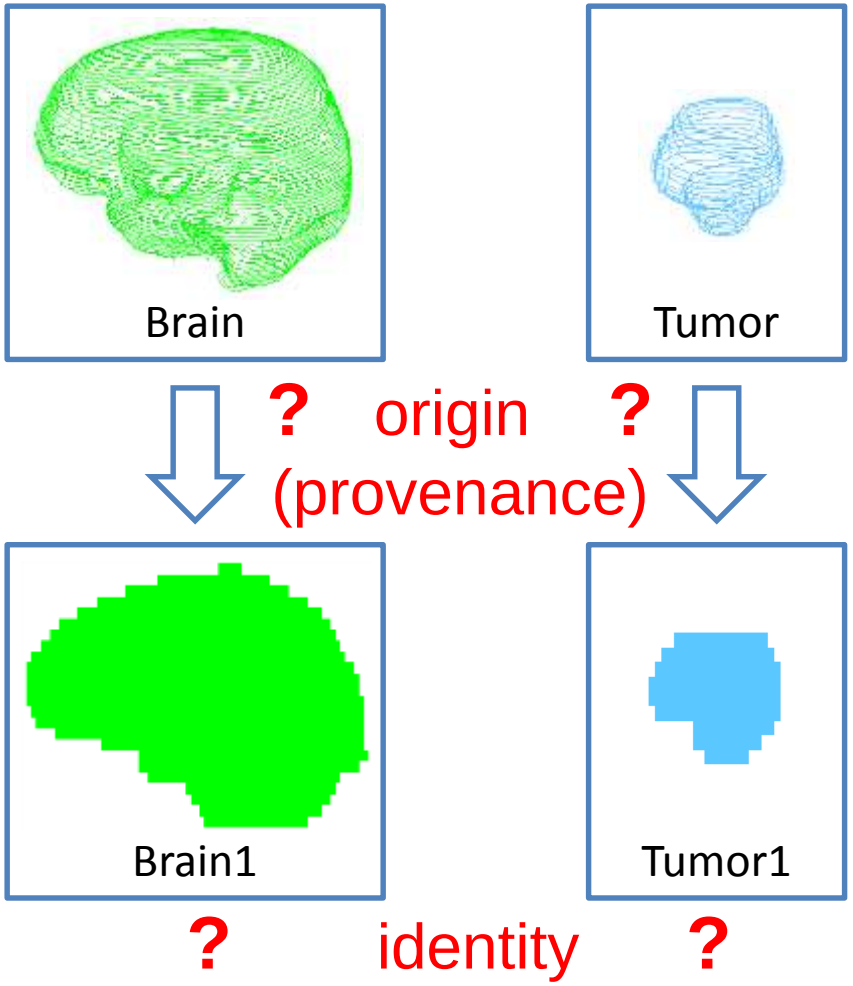



Analysis ✓

# Difficulty #2: Identity

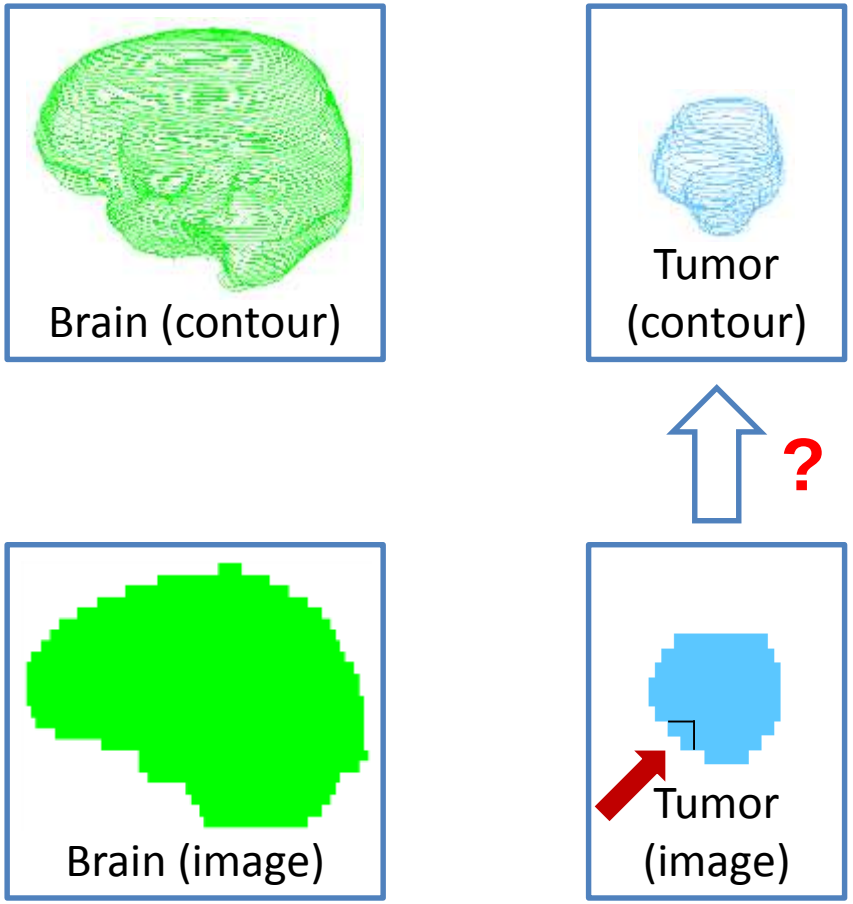
- Operation

- Identity
  - Need to keep track of where the structures came from and what they represent



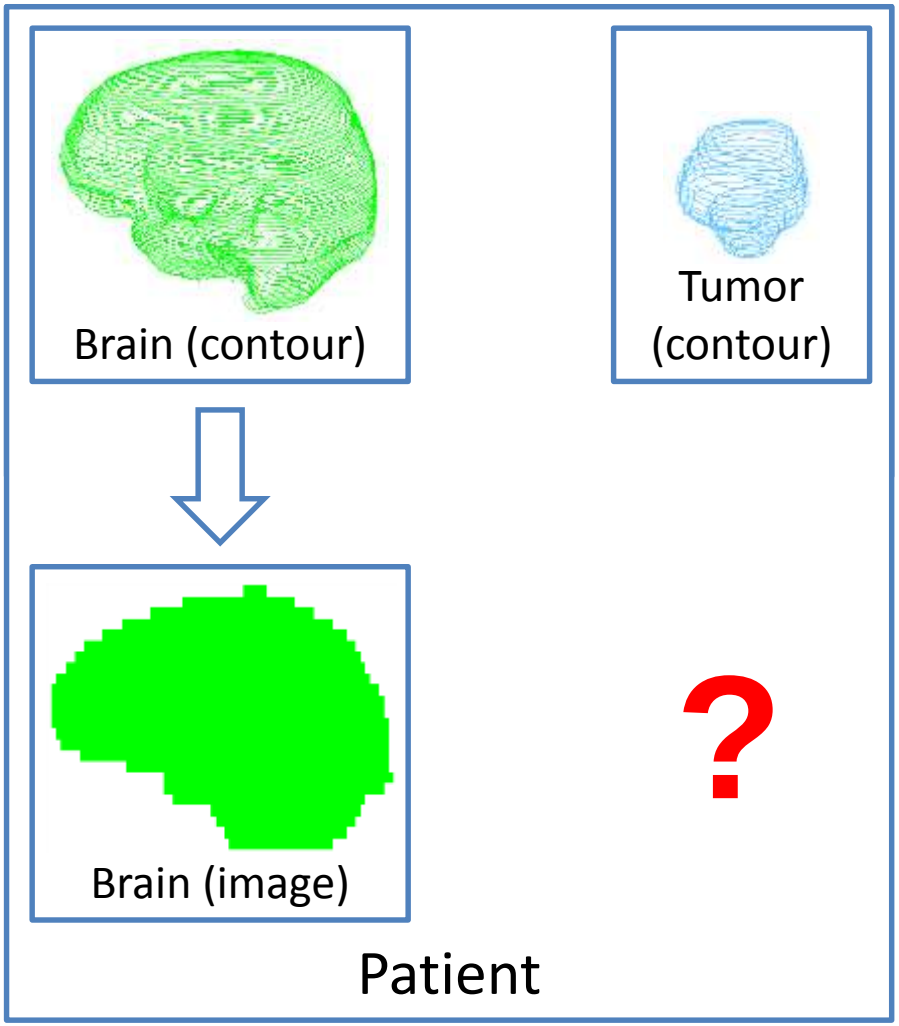
# Difficulty #3: Validity

- Operation
- Identity
- Validity
  - No invalid data should be accessible at any time



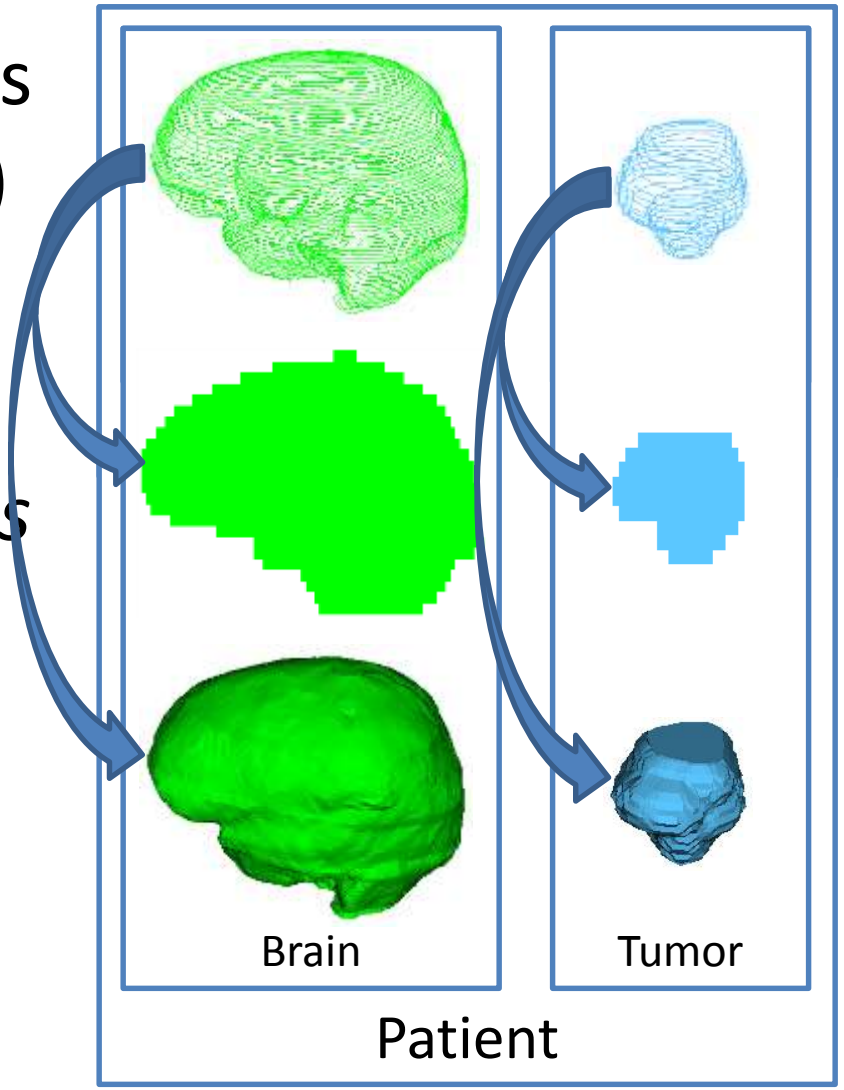
# Difficulty #4: Coherence

- Operation
- Identity
- Validity
- Coherence
  - Forming a unified whole



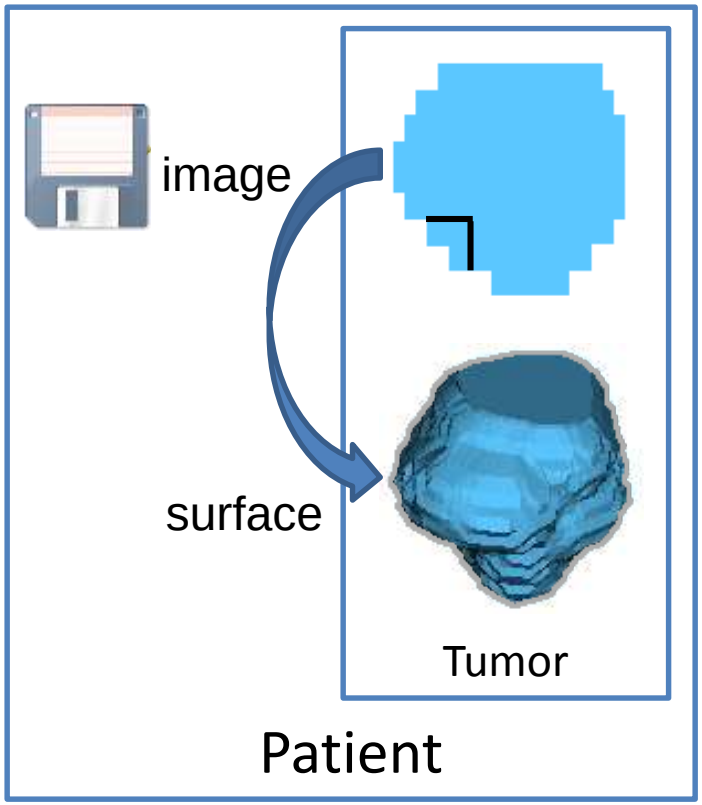
# Segmentation "object"

- 1 *segmentation* contains N *segments* (structures)
  - Coherence ✓
- Each *segment* contains multiple *representations*
  - Identity ✓
- Provides automatic conversions
  - Operation ✓



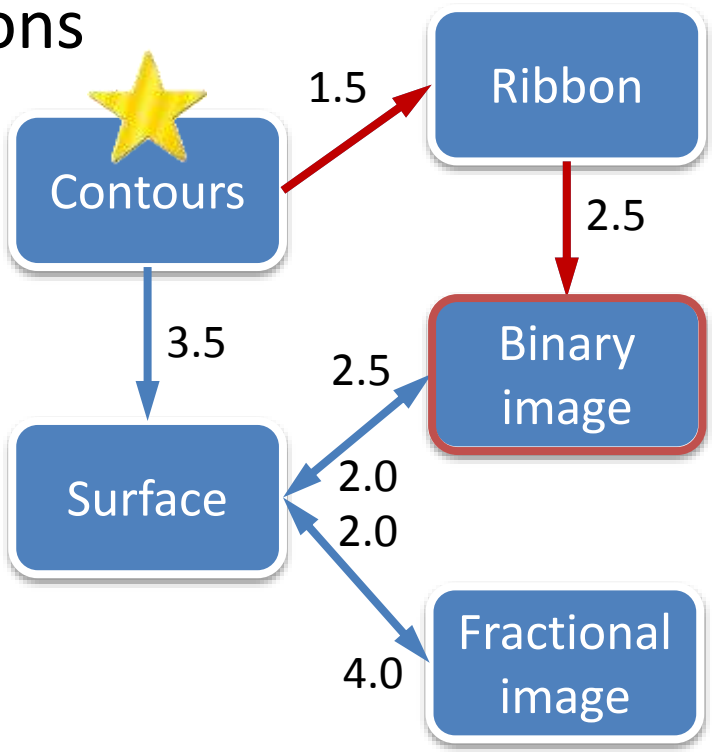
# Master representation

- "Promoted" representation
- Conversions use it as source
- When changed, the other representations are cleared
  - And re-converted as needed
- When saving to disk, this representation is written
- Solves Validity ✓



# Automatic conversion

- Driven by a dynamic graph
  - Nodes are the representations
  - Edges are the converters
    - Can be dynamically added
    - Can define representations
  - Cost metrics for edges
- Automatic conversion follows cheapest path
  - Happens when an absent representation is requested



# Implementation

- Software library SegmentationCore
  - Contains all the listed features
  - Uses only the VTK library
  - Can be integrated in many applications
- Segmentations module in SlicerRT
  - Advanced conversion options
  - Simultaneous real-time transformation
  - Advanced visualization in 2D and 3D
  - Extension of the 3D Slicer platform

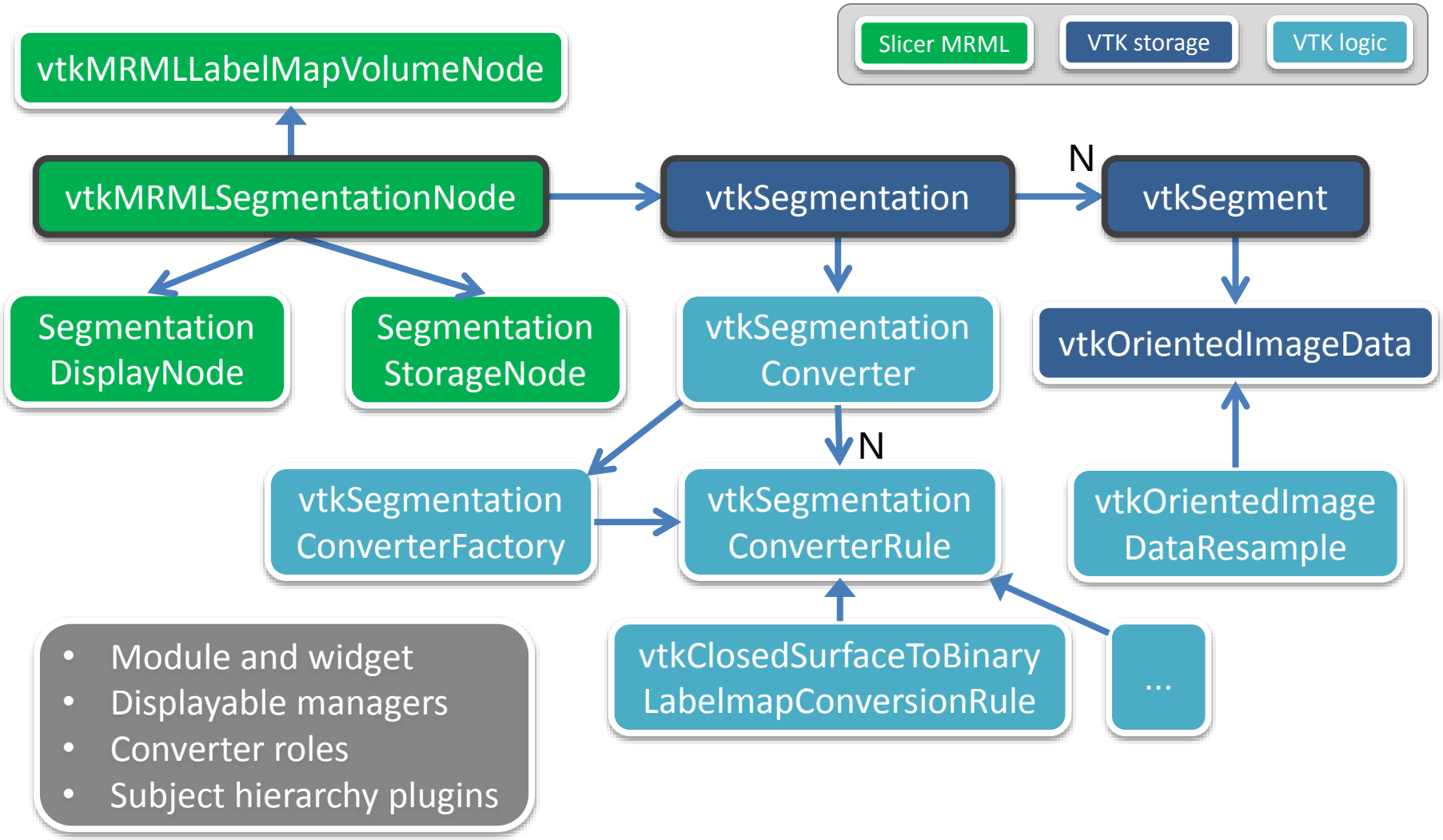
VTK

W. Schroeder *et al.* 2006

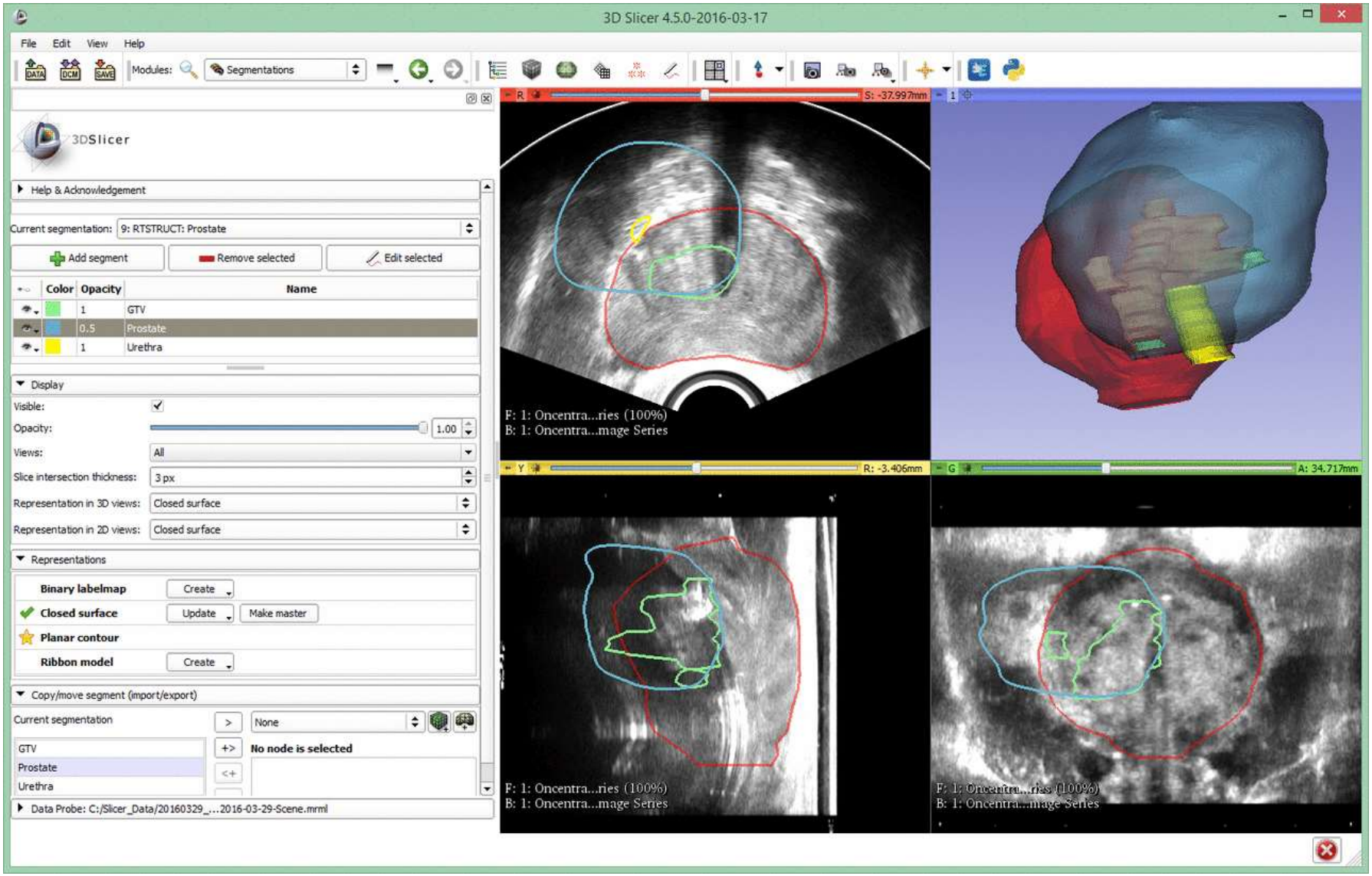
C. Pinter *et al.* 2012

A. Fedorov *et al.* 2012

# Architecture: 36 classes (C++)

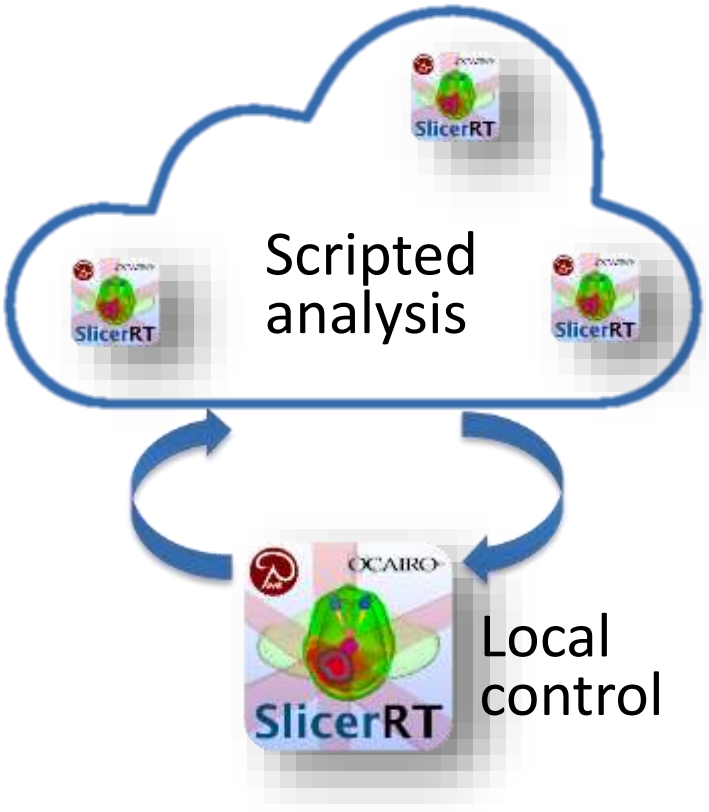


# Example use case: MRI/US fusion



# Example use case: Finding most similar RT plan in the cloud

- Initialize daily adaptive RT plan from most similar one
  - By geometrical similarity based on segmentation comparison
- Highly parallel computations
- Very large amount of data
- Self-driven scripts in cloud




*Andrea et al., IUPESM World Congress 2015*

# Future work

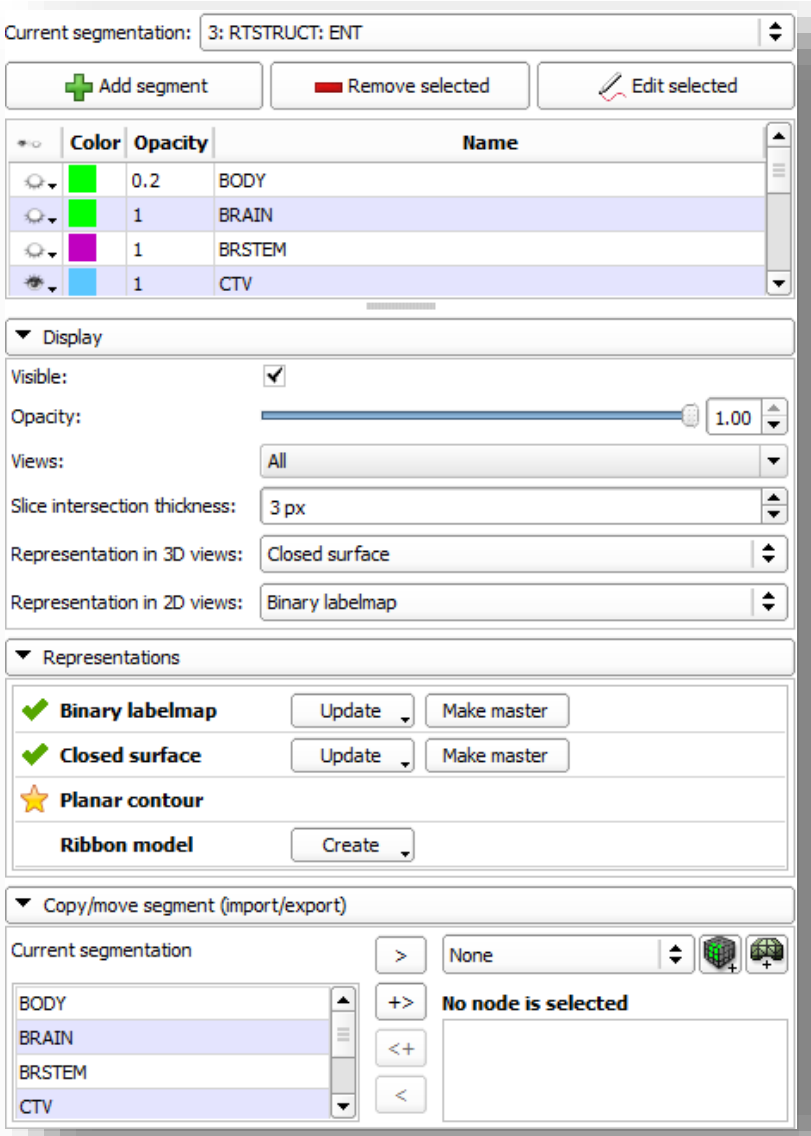
- Fractional image representation
  - More efficient storage of structures
  - Enables using stochastic methods
- Integration into 3D Slicer core
- Ontologies support
  - Hierarchical organization of structures
  - Standard ontologies used in clinics

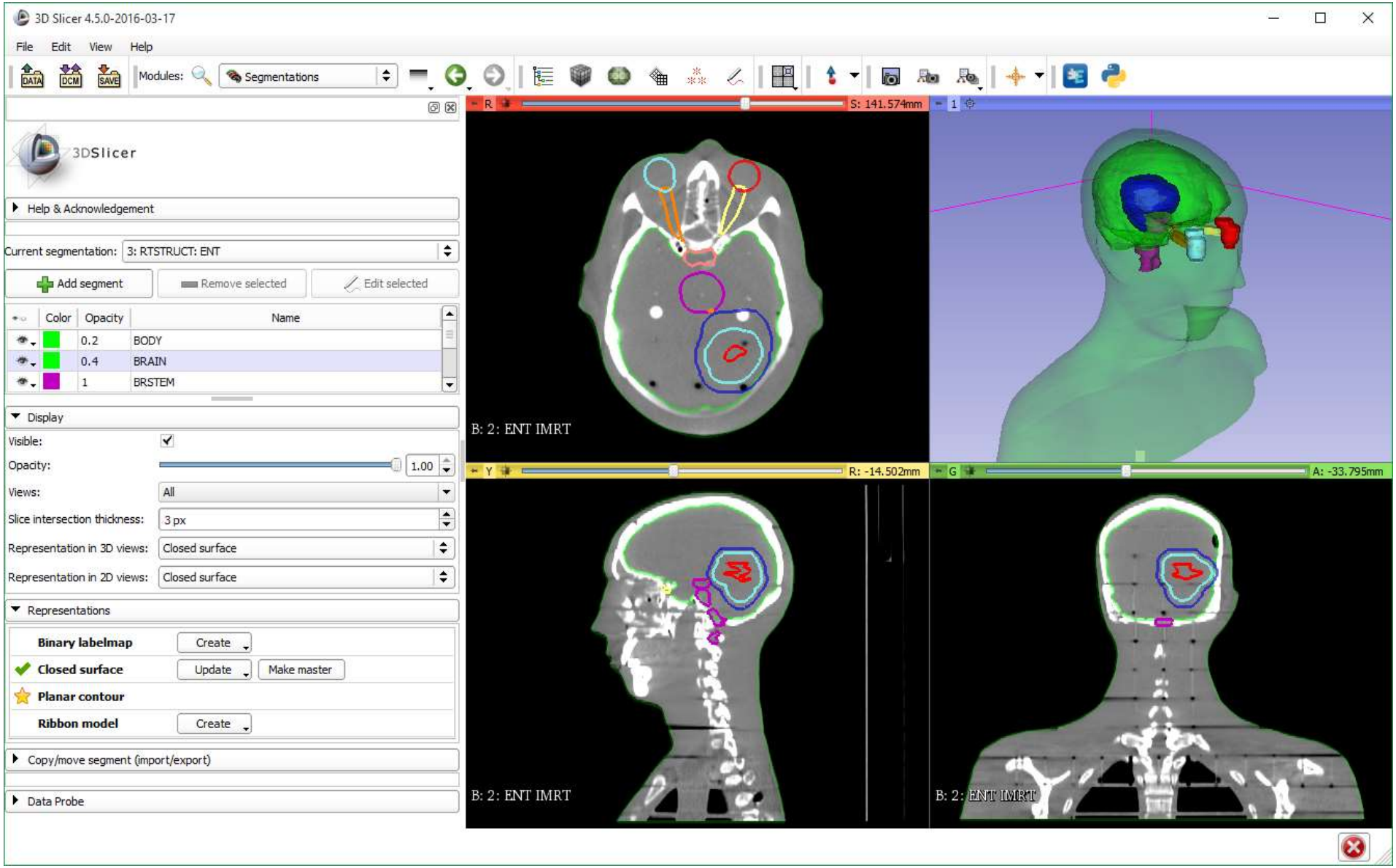
# Thank you for your attention!

# Appendix

# Segmentations user interface

- Managing segments and their properties
- Advanced display options
- Explicit handling of representations
- Convenient import/export




3D Slicer 4.5.0-2016-03-17
File
Edit
View
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Modules:
Segmentations
3DSlicer
Help & Acknowledgement
Current segmentation:
3: RTSTRUCT: ENT
Add segment
Remove selected
Edit selected
Color
Opacity
Name
0.2
BODY
0.4
BRAIN
1
BRSTEM
Display
Visible:
Opacity:
1.00
Views:
All
Slice intersection thickness:
3 px
Representation in 3D views:
Closed surface
Representation in 2D views:
Closed surface
Representations
Binary labelmap
Create
Closed surface
Update
Make master
Planar contour
Ribbon model
Create
Copy/move segment (import/export)
Data Probe
S: 141.574mm
B: 2: ENT IMRT
R: -14.502mm
A: -33.795mm
B: 2: ENT IMRT
B: 2: ENT IMRT

# Difficulties with conversion

- Operation: User needs to know that conversion is needed, and how to perform the conversion
- Identity: Relationships between converted objects need to be preserved to be able to determine their origin and identity
- Validity: When a representation changes, the others need to follow, otherwise invalid data is accessible
- Coherence: Structures belonging together must be converted together to contain the same data types