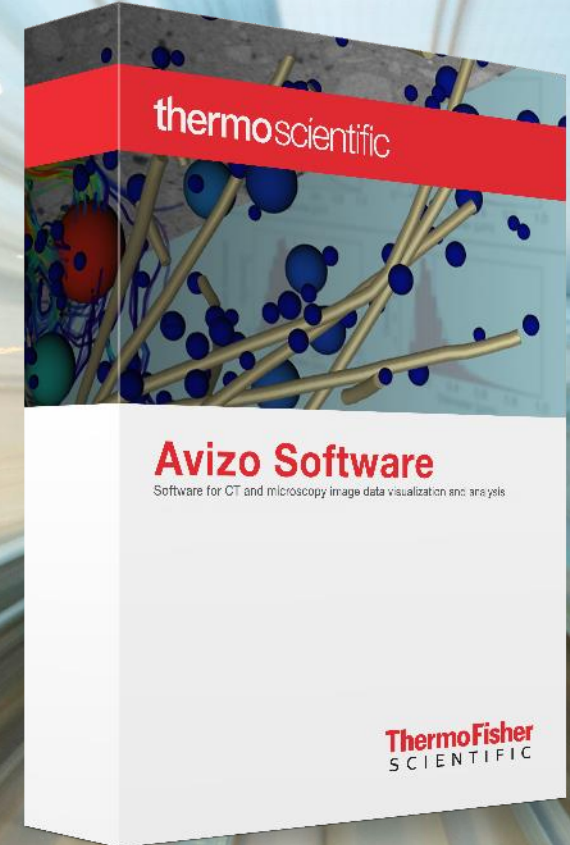


Avizo Software Introductory Training

Sarawuth Wantha

Product Application Specialist

 The world leader in serving science



A quick word about me



Sarawuth Wantha

Avizo Software Product Application Specialist

Thermo Fisher Scientific

Bordeaux France

- Master's degree in Biomedical Engineering, RWTH Aachen University, Germany
- Doctoral degree, Ludwig-Maximilians-University Munich, Germany
- Ph.D. in Biomedical Engineering with the focus on Biomedical Imaging Modalities and Image Processing.
- Research techniques: X-Ray CT, MRI, Electron microscopy, Fluorescence Imaging (confocal, light-sheet, multi-photon, STED microscopy).
- Post-Doctoral research: Cardiac Electrophysiology & Stem Cell-derived Cardiomyocytes.
- Extensive experience in image processing software.

World leader in serving science



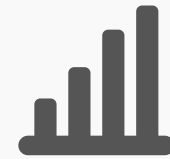
>80,000
employees



5,700
R&D scientists/engineers



>\$1B
invested in R&D



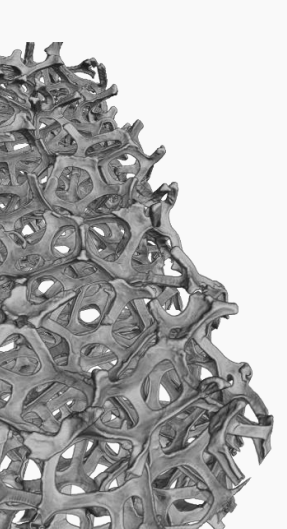
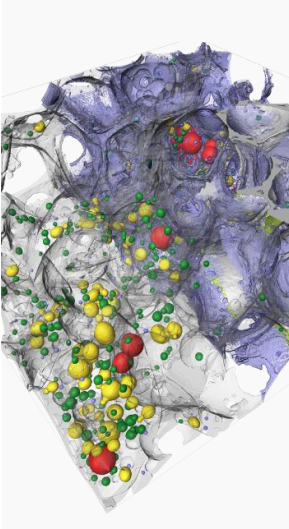
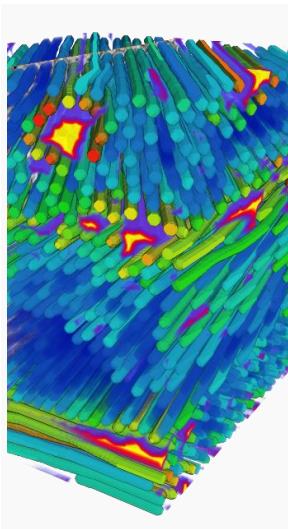
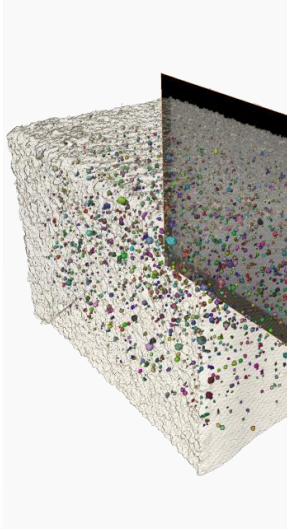
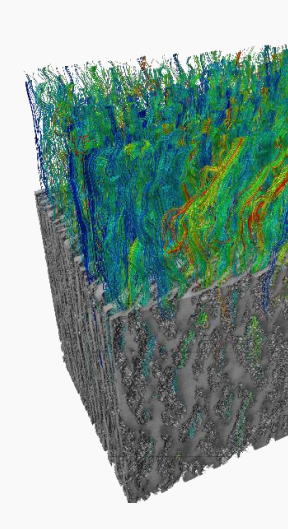
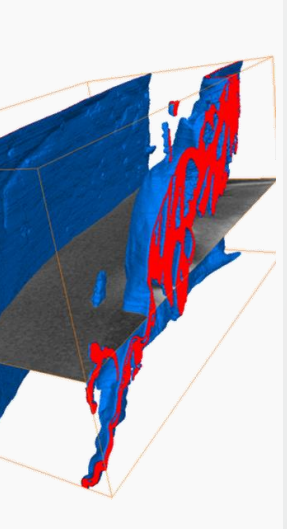
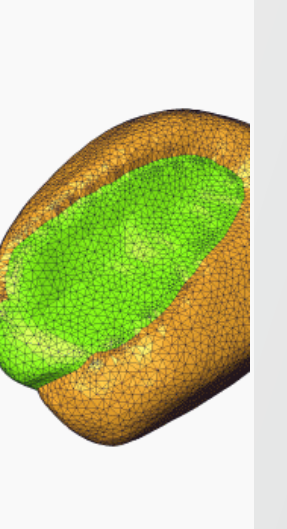
>\$30B
in revenue

We take pride in our Mission

We enable our customers
to make the world healthier,
cleaner and safer

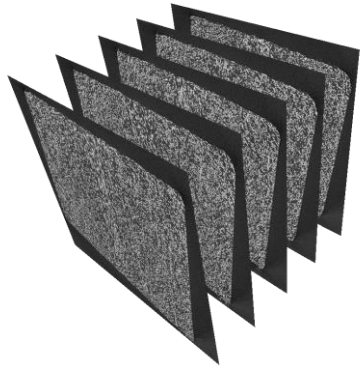
Avizo Software for Materials Research & Quality Control

Quickly and accurately obtain properties from your imaging data

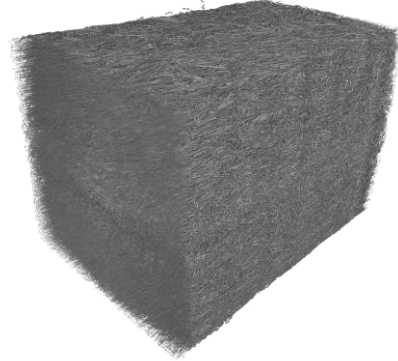
Metals and Alloy	Ceramics, Glasses and Porous	Composite, Polymer	Additive Manufacturing	Battery Energy Materials	Biomaterials	Food and Agriculture
						

Avizo Software provides unmatched imaging data analysis tools for numerous scientific and industrial applications from a single environment

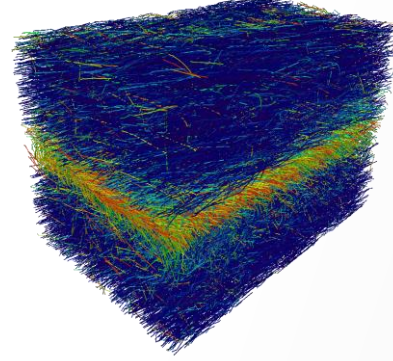
From images to knowledge



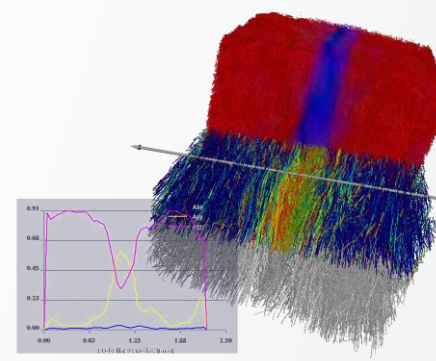
Import



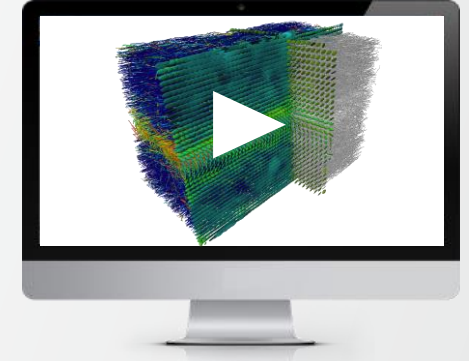
Visualization



Segmentation



Measurements and
analysis



Presentation



Data acquisition

From imaging data, our software tools create numerical 3D models that can be visualized and analyzed to understand the structure, properties and behaviors of live or materials samples

Agenda

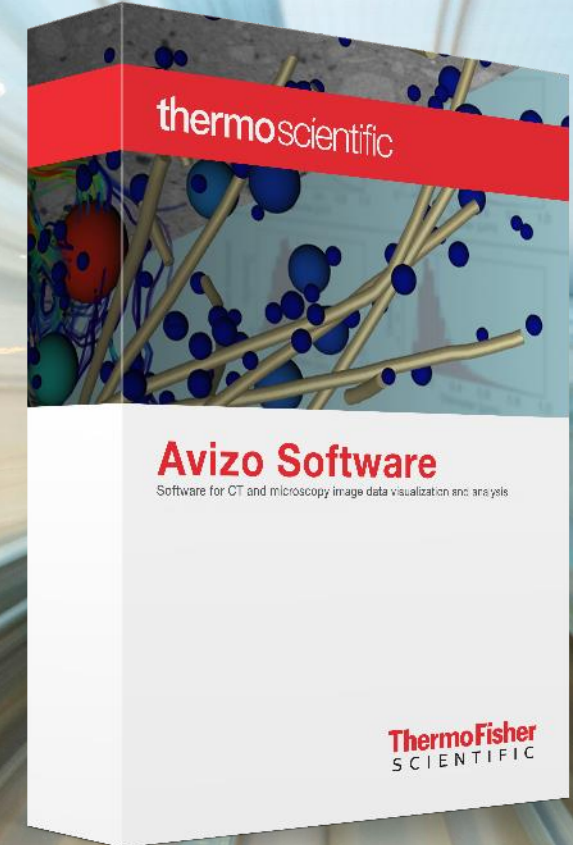
1 General concepts

2 Visualization & Image Pre-Processing

3 Segmentation

4 AI Capabilities

5 Advanced topics



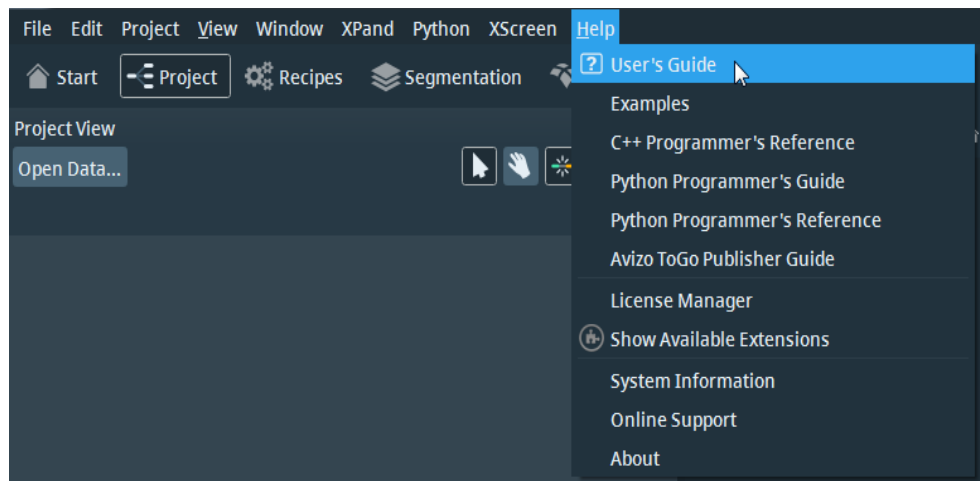
General concepts and tools

Getting started

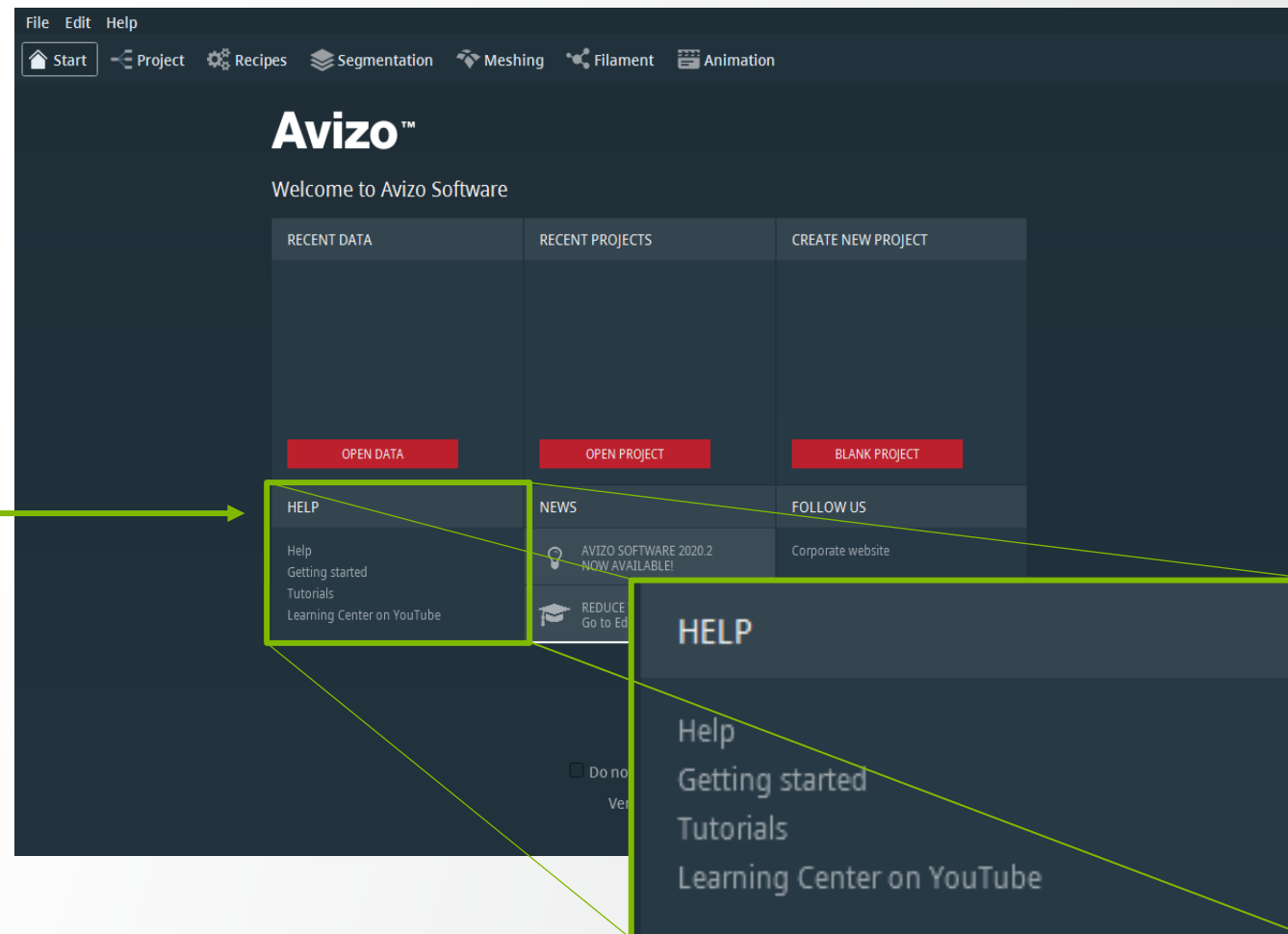
Help menu access

Learning resources:

- Tutorials
- YouTube Learning Center
- User's Guide



Avizo start page access

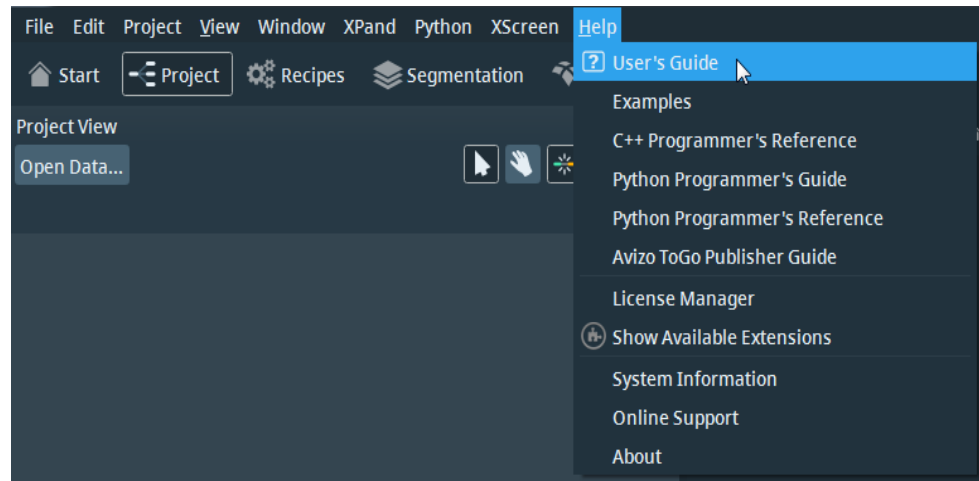


Getting started

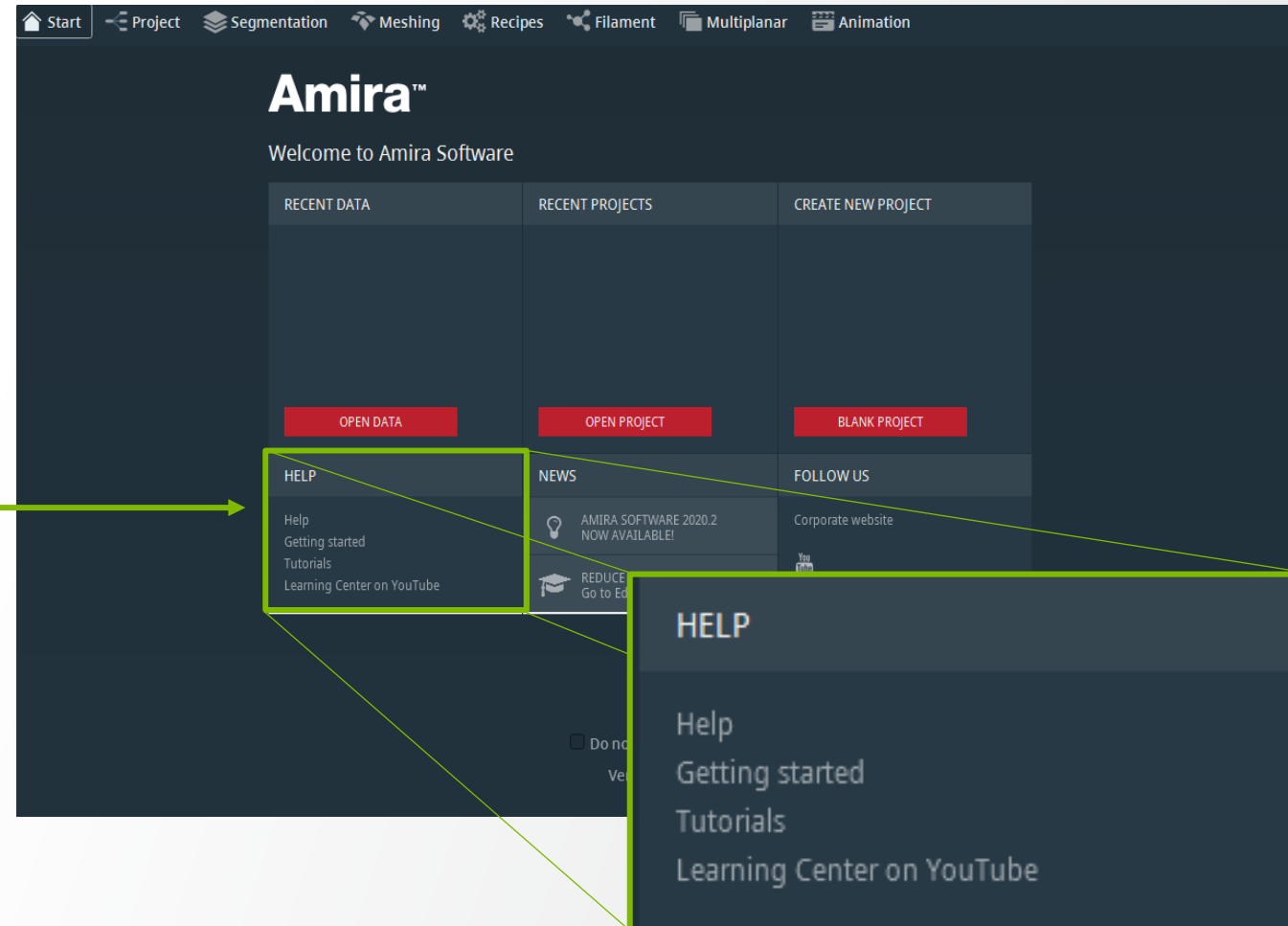
Help menu access

Learning resources:

- Tutorials
- YouTube Learning Center
- User's Guide



Amira start page access



Avizo start-up page

File Edit Help

Start Project Recipes Segmentation Meshing Filament Animation

Avizo™

Welcome to Avizo Software

RECENT DATA	RECENT PROJECTS	CREATE NEW PROJECT
OPEN DATA	OPEN PROJECT	BLANK PROJECT
HELP	NEWS	FOLLOW US
Help Getting started Tutorials Learning Center on YouTube	AVIZO SOFTWARE 2020.2 NOW AVAILABLE! REDUCE YOUR LEARNING CURVE Go to Education Center	Corporate website

Do not show at startup

Version 2020.2

Amira start-up page



Amira - Untitled

File Edit Help

Start Project EM Project Segmentation Meshing Recipes Filament Multiplanar Animation

Amira™

Welcome to Amira Software

RECENT DATA	RECENT PROJECTS	CREATE NEW PROJECT
OPEN DATA	OPEN PROJECT	BLANK PROJECT

HELP

- Help
- Getting started
- Tutorials
- Learning Center on YouTube

NEWS

- AMIRA SOFTWARE 2020.3 NOW AVAILABLE!
- QUICKLY GET UP TO SPEED Go to XTra Resource Library

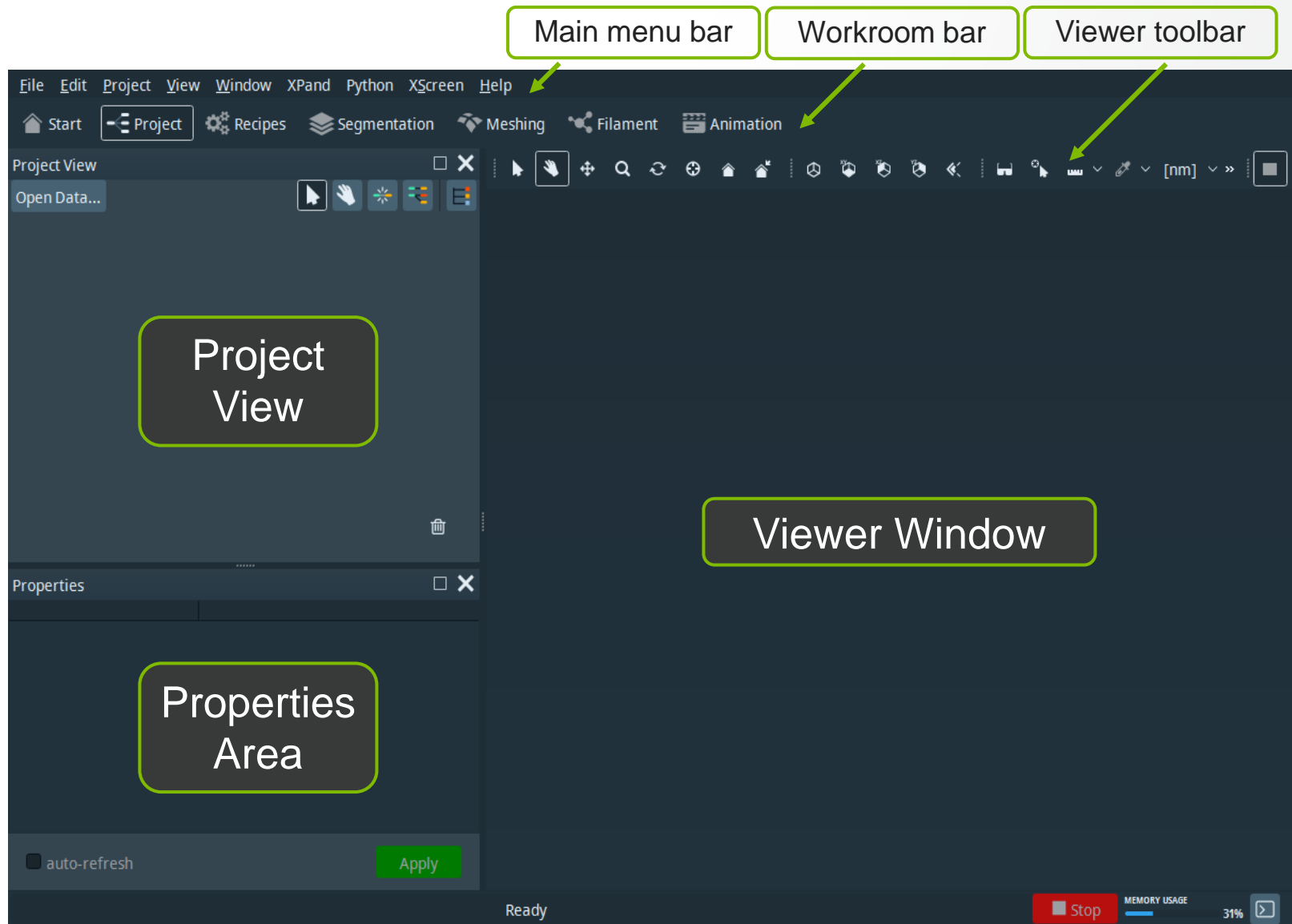
FOLLOW US

- Corporate website
- YouTube

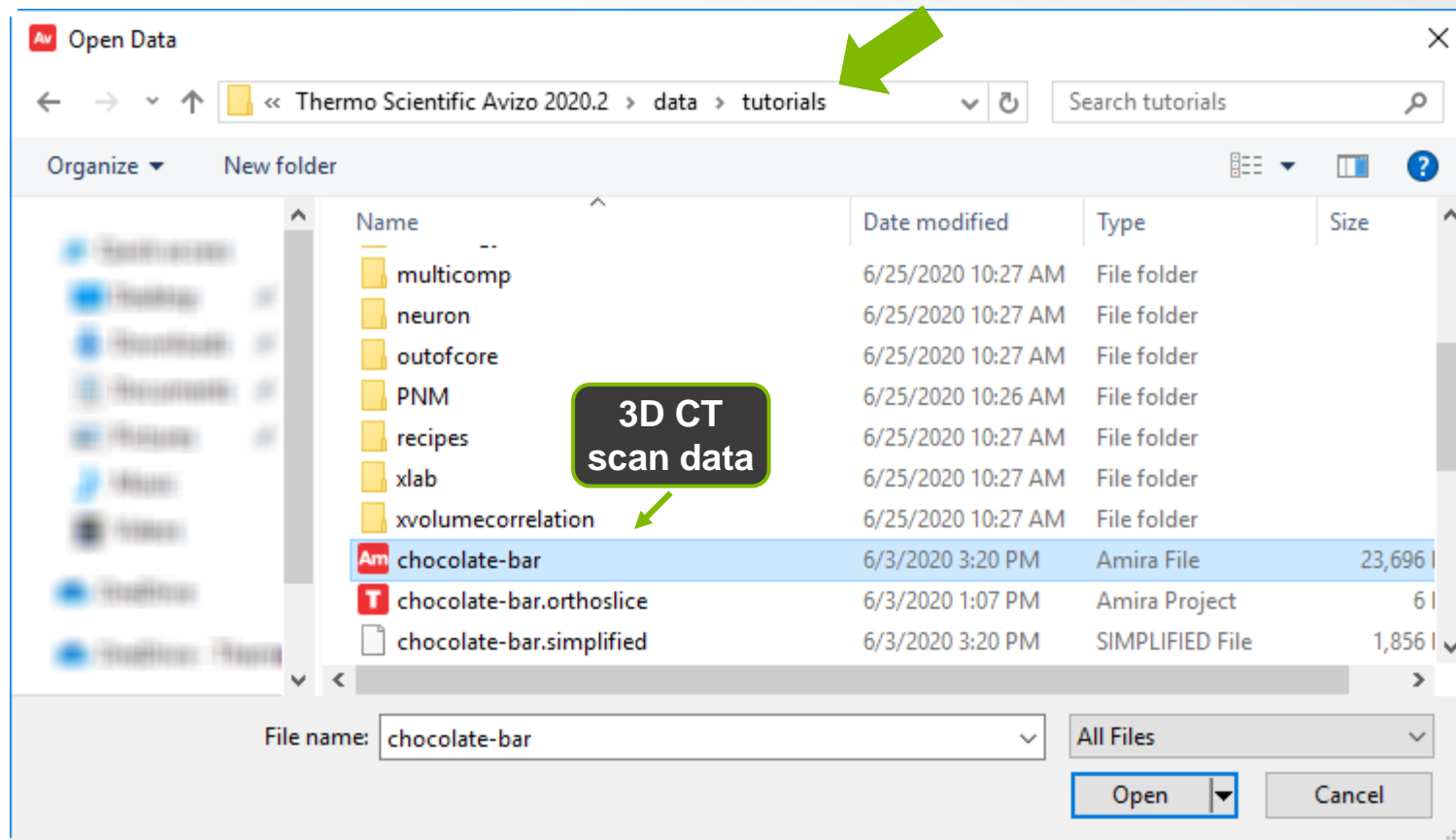
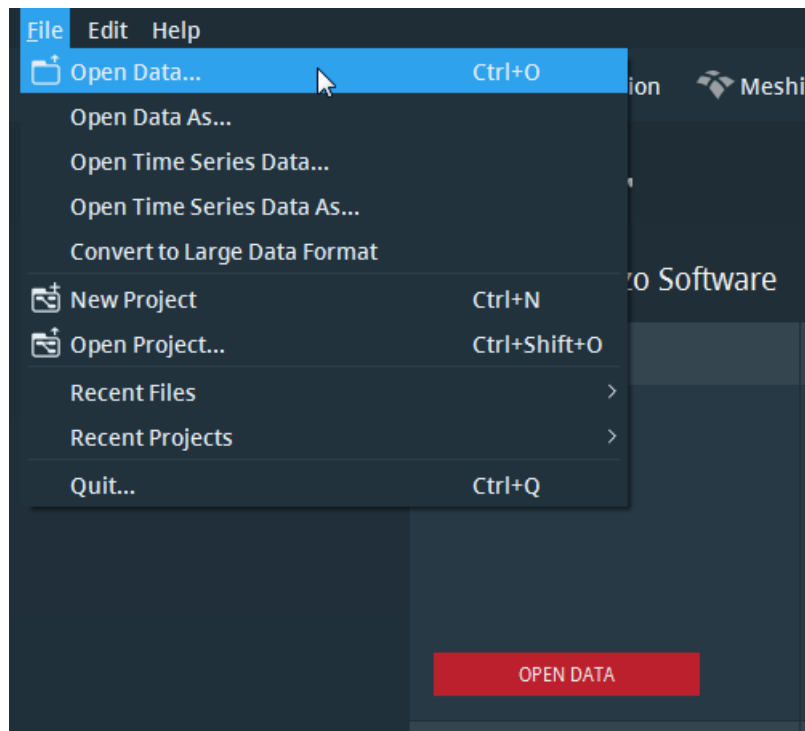
Do not show at startup

Version 2020.2

Workspace: user interface components



Loading a dataset into Project Workroom – part 1



Loading a dataset into the Project Workroom – part 2

The screenshot displays the Project Workroom software interface. The top menu bar includes File, Edit, Project, View, Window, XPand, Python, XScreen, and Help. Below the menu is a toolbar with icons for Start, Project, Recipes, Segmentation, Meshing, Filament, and Animation. The Project View panel on the left shows a list of data objects, with 'chocolate-bar.am' selected. A green box highlights this object, and a label 'Data object' points to it. To its right, 'Ortho Slice' is selected, and a label 'Display module' points to it. A green box highlights the 'Ortho Slice' label, and a text box above it reads 'Default data display Configuration: Edit>Preferences> Auto Display'. The Properties panel on the left shows the configuration for the 'Ortho Slice' module, including Data (chocolate-bar.am), Orientation (xy), Slice Number (147), Mapping Type (Colormap), Colormap (0 to 1910), and Options (adjust view, show width: 1). The main view area shows a grayscale image of a chocolate bar slice. The bottom status bar shows 'Ready', a 'Stop' button, 'MEMORY USAGE' at 34%, and a refresh icon.

File Edit Project View Window XPand Python XScreen Help

Start Project Recipes Segmentation Meshing Filament Animation

Project View

Open Data...

Contrast Control Roi Slice Voxel Slice Cylinder Slice

chocolate-bar.am Ortho Slice

Data object Display module

Default data display
Configuration: *Edit>Preferences> Auto Display*

Ortho Slice

Data: chocolate-bar.am

Orientation: xy xz yz

Slice Number: 147

Mapping Type: Colormap

Colormap: 0 1910

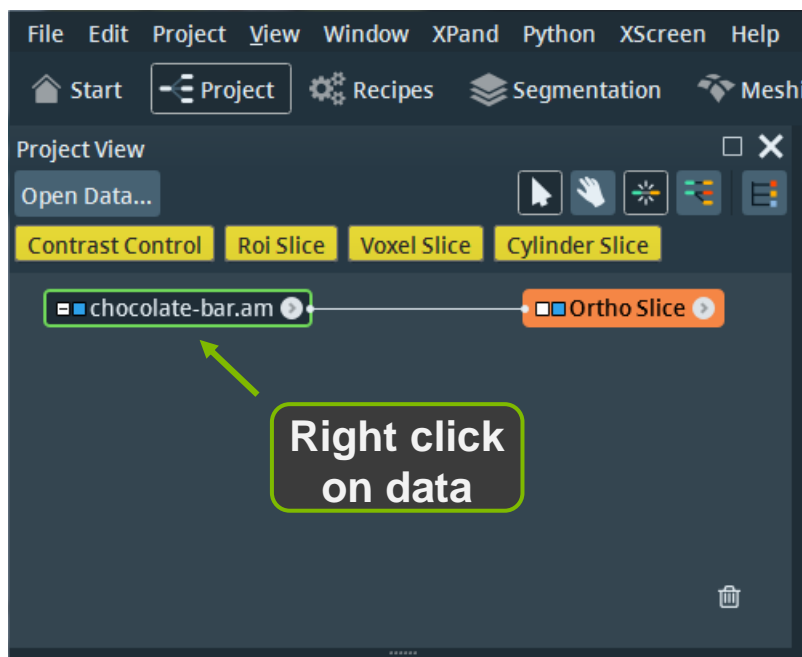
Options: adjust view bilinear view lighting

Frame: show width: 1

auto-refresh Apply

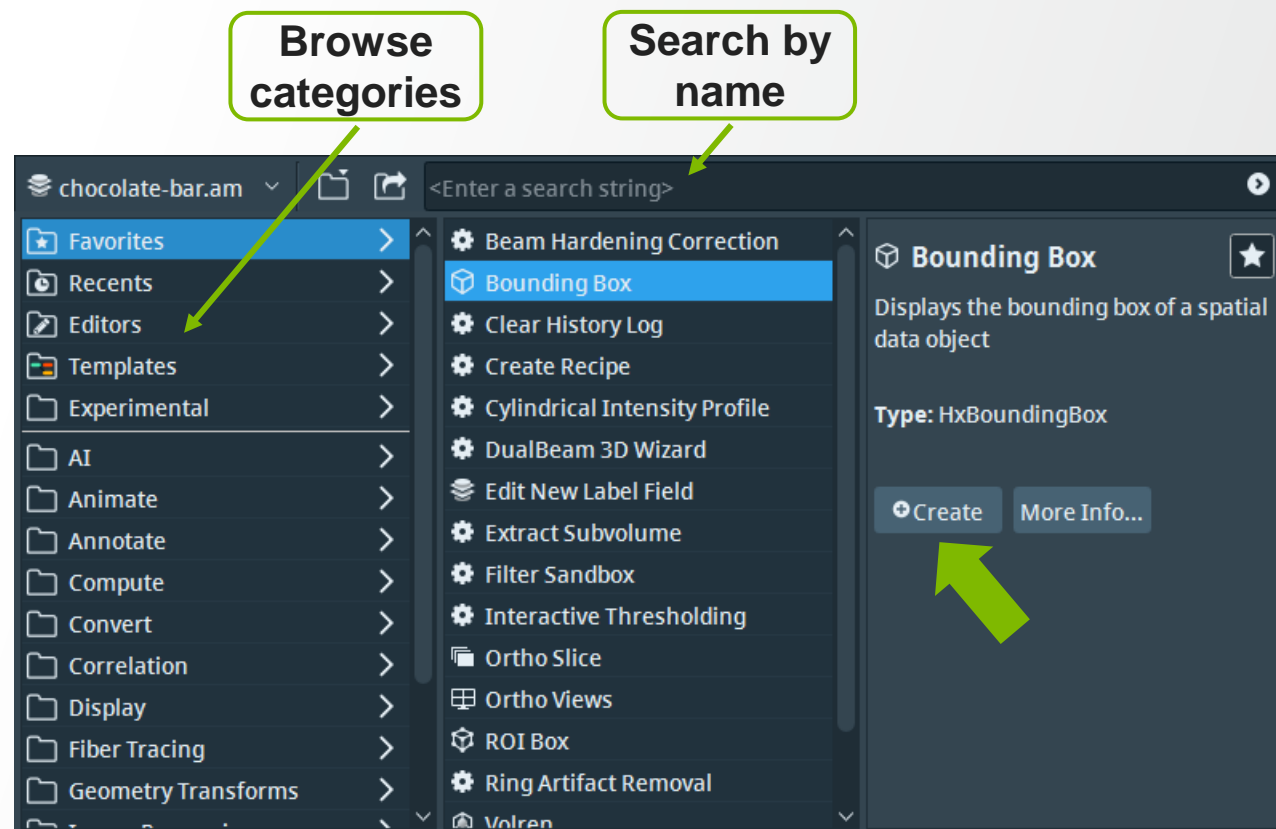
Ready Stop MEMORY USAGE 34%

Attach a module to a dataset: e.g. Bounding Box



Ways to trigger module:

- Double-click
- Press Enter
- Press Create button



Module properties: e.g. Bounding Box

The screenshot displays the software interface with a 3D view of a chocolate bar slice and its bounding box. The Project View on the left shows a tree structure with 'chocolate-bar.am', 'Ortho Slice', and 'Bounding Box'. The Properties panel at the bottom left is open for the 'Bounding Box' module, showing fields for Data, Lower Left, Upper Right, Line Width, Options, and Font. A green callout box points to the '?' icon in the Properties panel, labeled 'Access documentation'. Another green callout box points to the 'Bounding Box' module in the Project View, labeled 'Properties of the objects selected in the Project View'. The 3D view shows a bounding box with coordinates (0, 0, 0 [nm]) at the top-left corner and (2.808e+7, 2.093e+07, 3.528e+07 [nm]) at the bottom-right corner.

Properties of the objects selected in the Project View

Access documentation

0, 0, 0 [nm]

2.808e+7, 2.093e+07, 3.528e+07 [nm]

Ready

Stop MEMORY USAGE 29%

Properties:

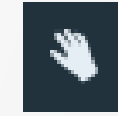
- Click on a module in the pool to display its **properties** (data module included)
- Click on “?” to access the module’s **documentation**
- Module properties are called **ports**

Navigate and interact in 3D – part 1

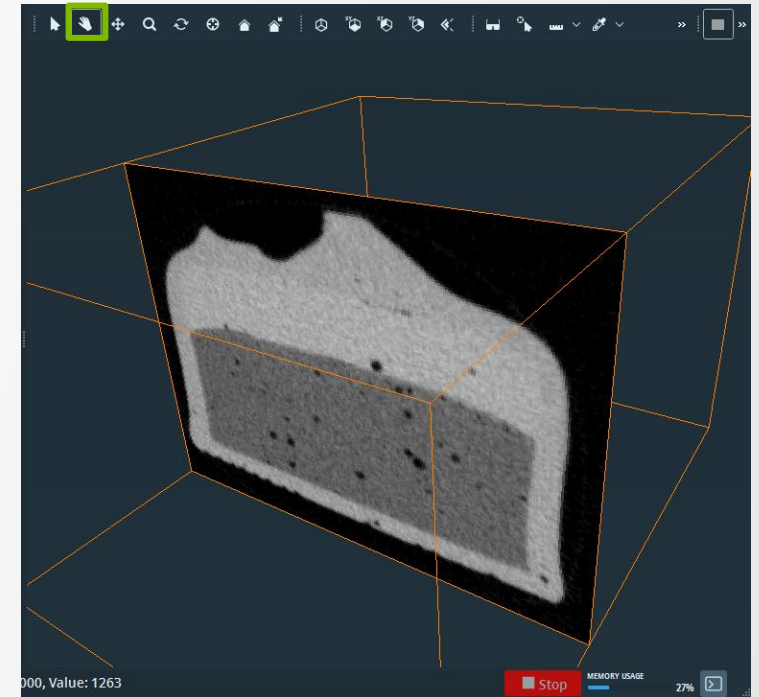
Bounding Box
Original View



Interact
[ESC]



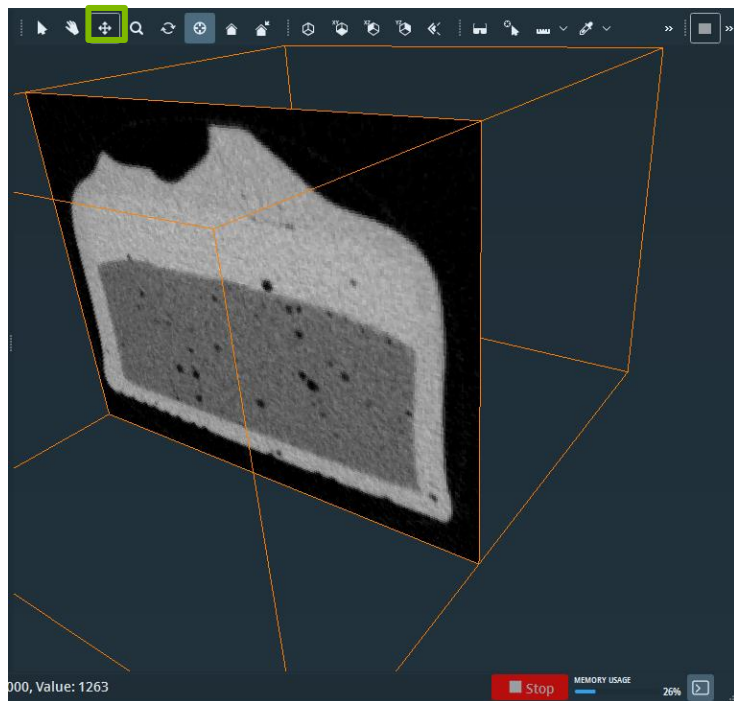
Trackball
[ESC], [Alt]



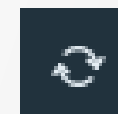
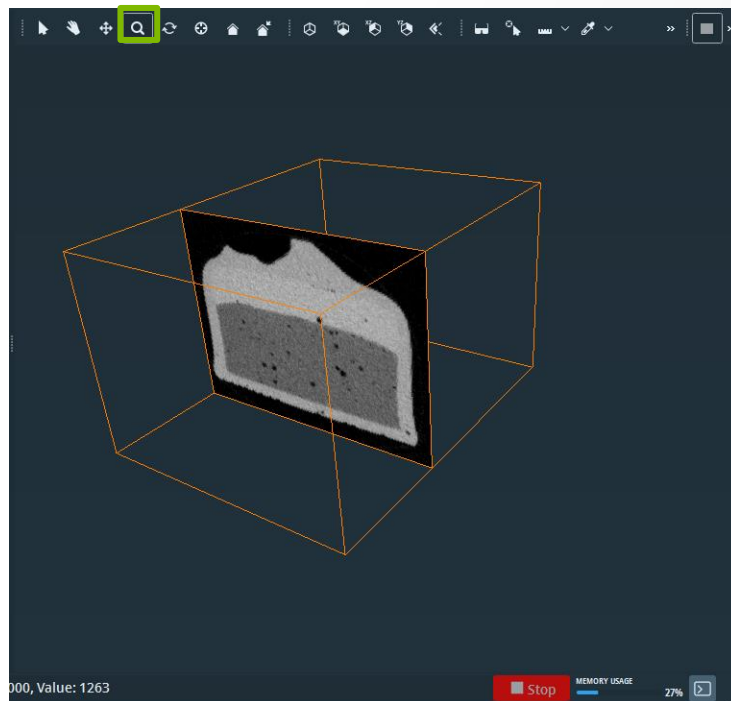
Navigate and interact in 3D – part 1



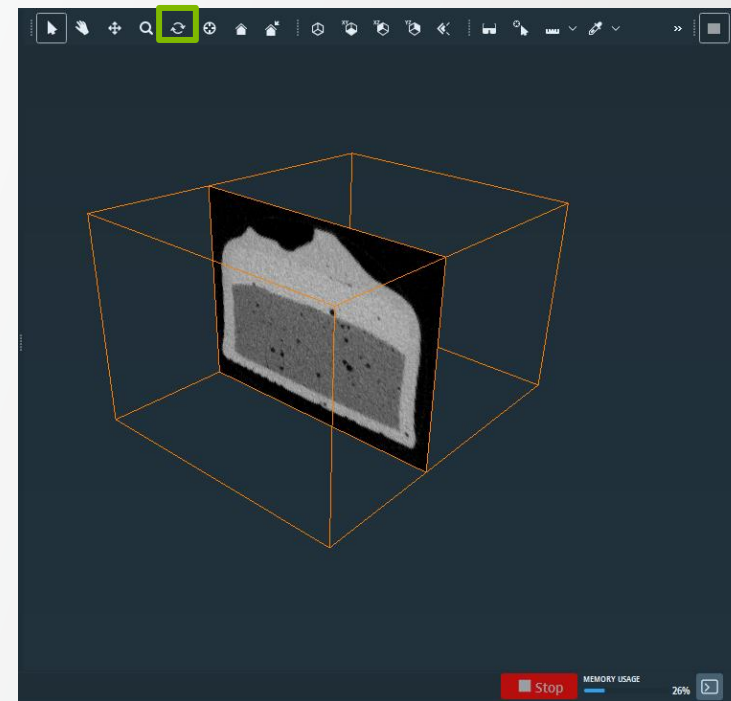
Translate
Left mouse button



Zoom
Mouse wheel/left button



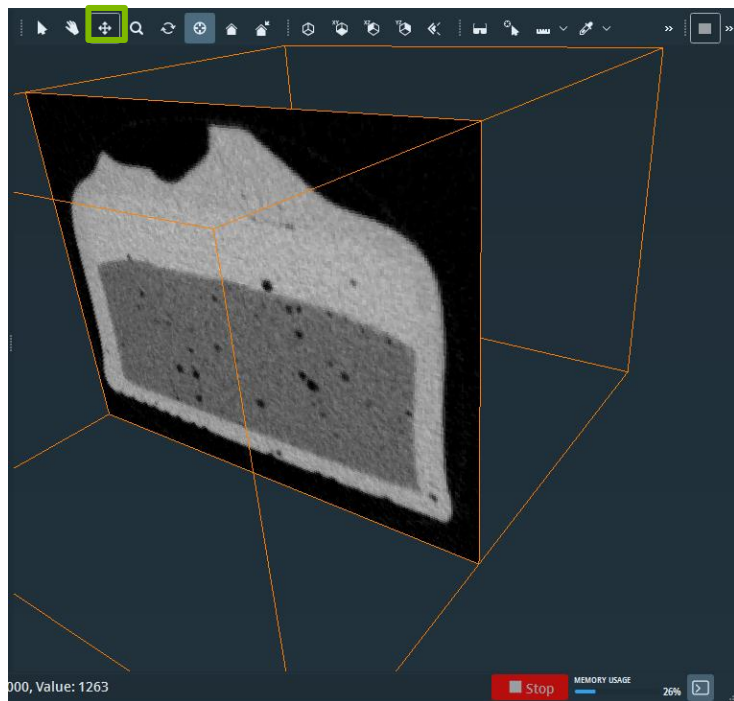
Rotate
Click icon /+ [Shift]/[Ctrl]



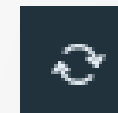
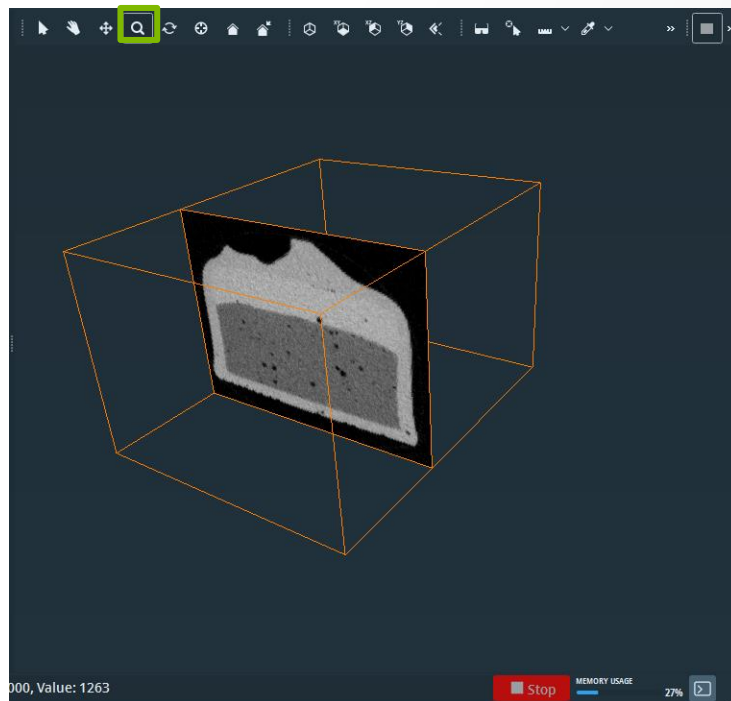
Navigate and interact in 3D – Part 2



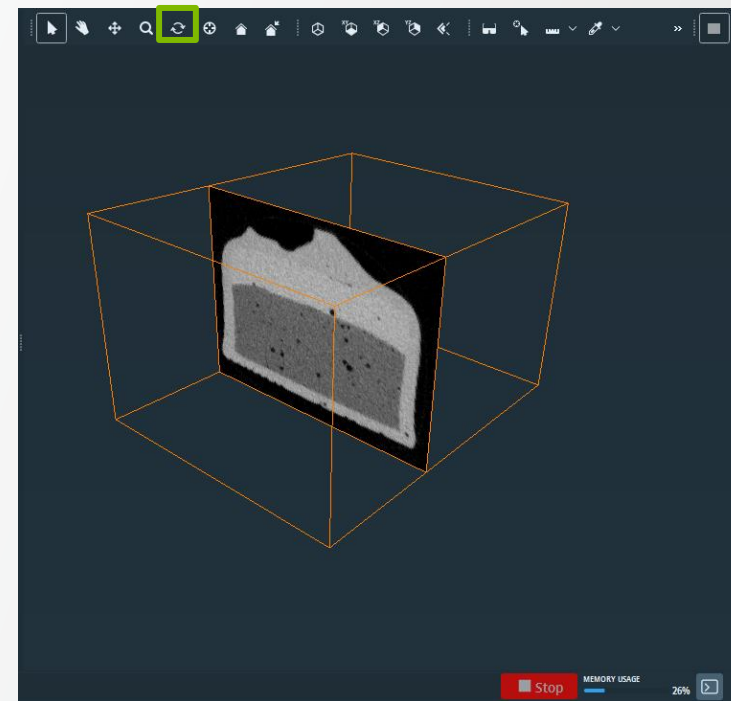
Translate
Left mouse button



Zoom
Mouse wheel/left button



Rotate
Click icon /+ [Shift]/[Ctrl]



Navigate and interact in 3D – good practice

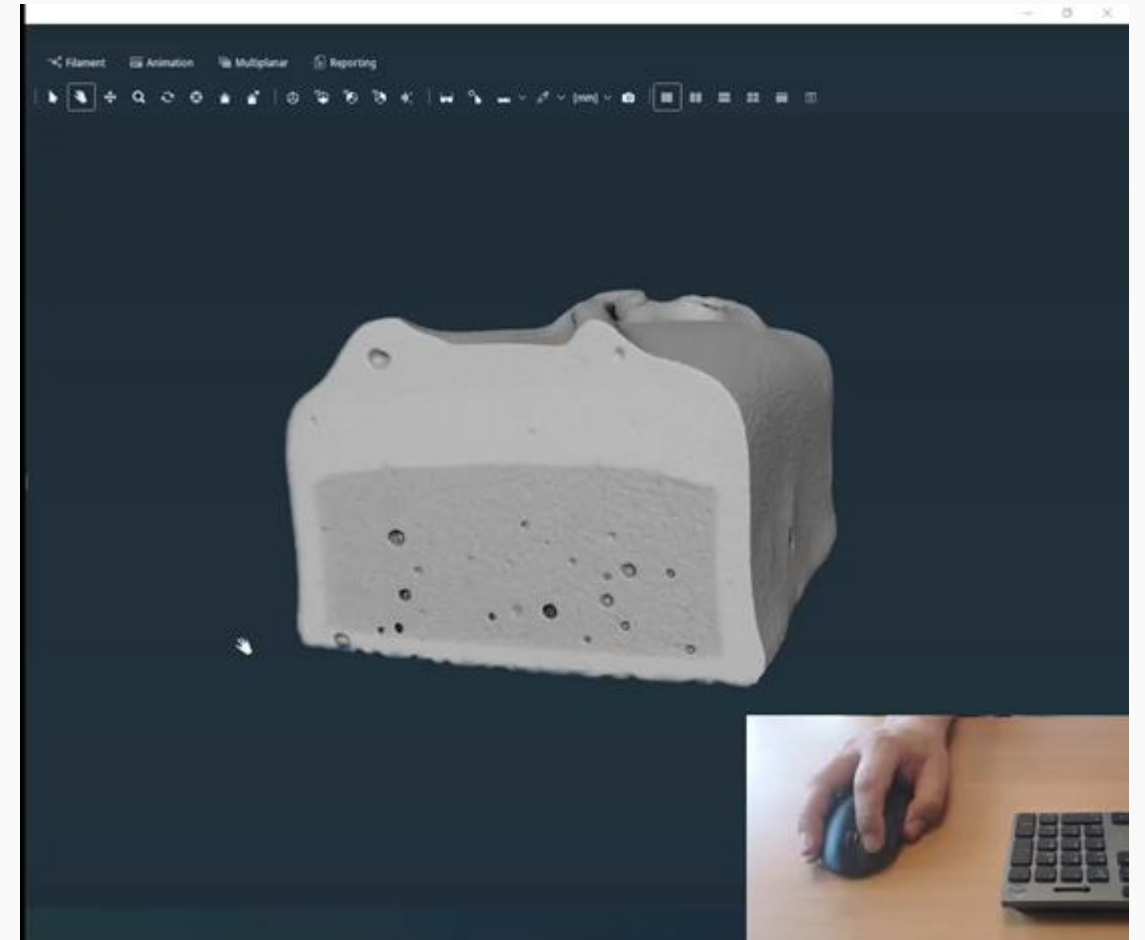
Most of the actions can be done in the **trackball mode**:

- Hold left mouse button for **rotation**
- Use the mouse wheel for **fine zoom**
- Hold left and middle mouse button for **fast zoom**
- Hold the middle mouse button for **translation**

When in **interact mode**:

- Press and hold [Alt] to switch to trackball mode

Press [Esc] for switching between interact and trackball modes.



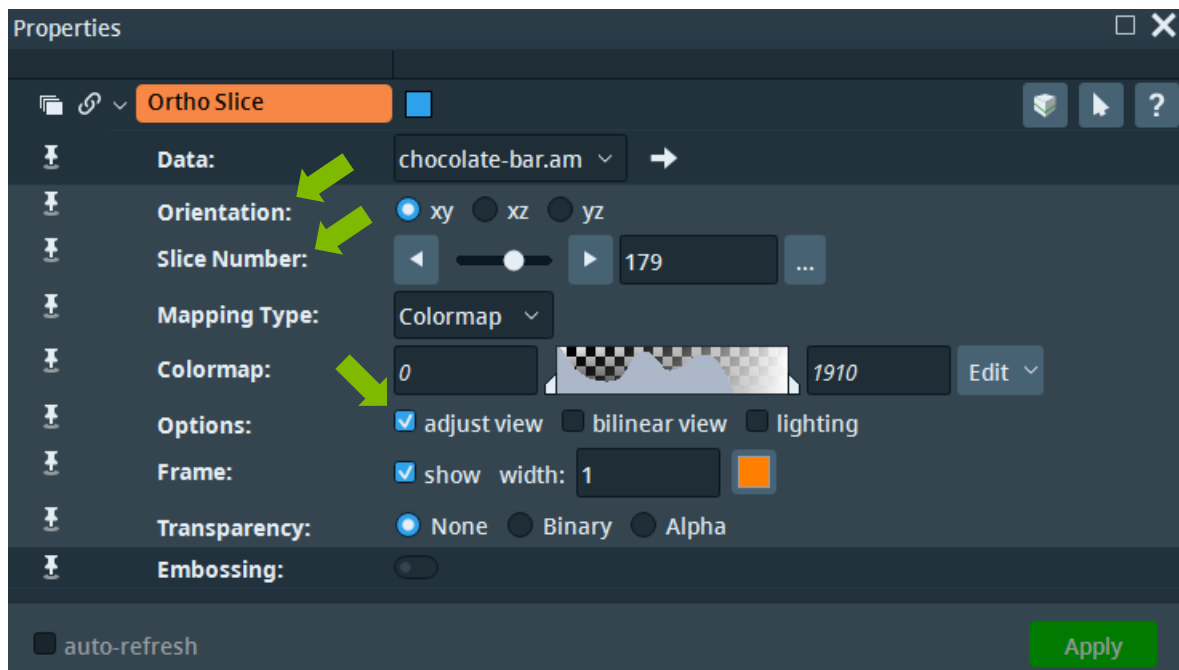
Visualize a dataset: e.g. Ortho Slice

The screenshot displays the software interface with the following components:

- Project View:** Shows a workflow with 'chocolate-bar.am' and 'Ortho Slice' modules. A callout box with the text 'Turn visibility on/off' points to the 'Ortho Slice' module.
- Properties Panel:** Configured for the 'Ortho Slice' module with the following settings:
 - Data: chocolate-bar.am
 - Orientation: xy (selected)
 - Slice Number: 147
 - Mapping Type: Colormap
 - Colormap: 0 to 1910
 - Options: adjust view, bilinear view, lighting
 - Frame: show width: 1
- 3D View:** Displays a grayscale slice of a chocolate bar.
- Status Bar:** Shows 'Ready', a 'Stop' button, and 'MEMORY USAGE 34%'.

- Ortho Slice connects Automatically if **Auto Display** is on
- Can otherwise be **created** like any other module
- A dataset is displayed in the viewer only if it has a **visualization module** attached
- Check that **visibility** is **turned on** (e.g. workflow with multiple data)

Visualize a Dataset: e.g. Ortho Slice properties



Some properties settings:

- **Orientation** port: choose the display plane of the slice
- **Slice number**: choose the slice to be displayed in the viewer - drag slider or use mouse wheel / insert value in the text box
- **Adjust view**: if **on**, the camera is reset each time a new slice orientation is selected

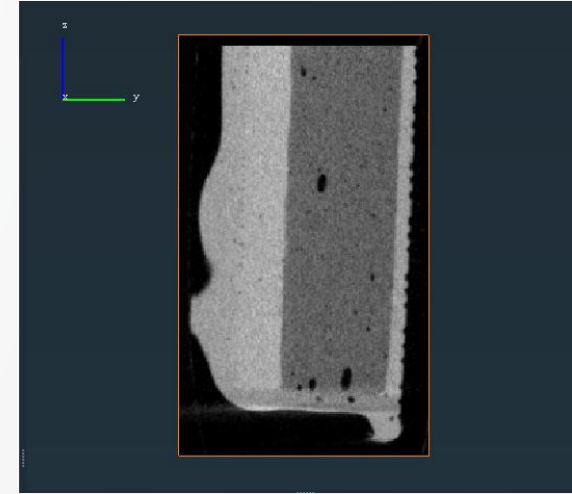
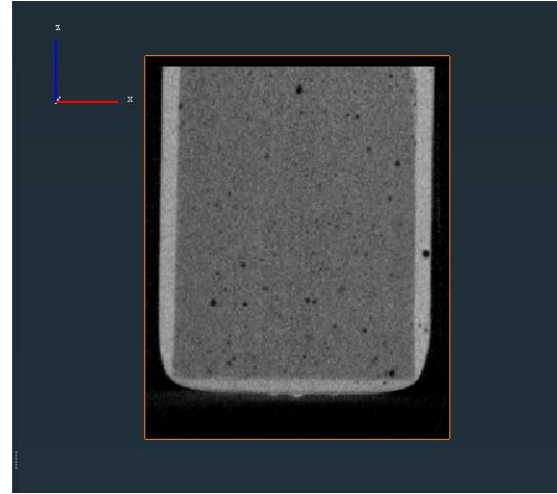
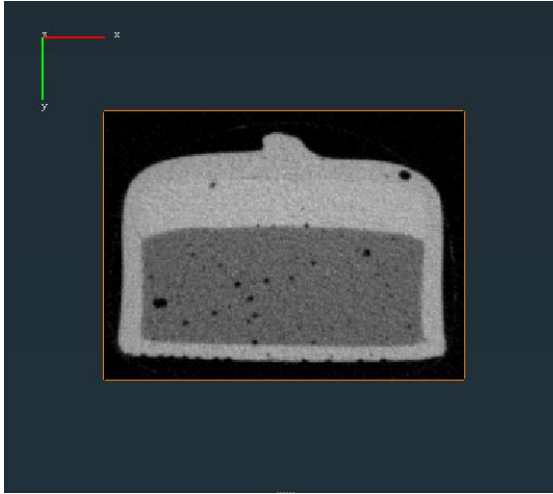
Visualize a Dataset: e.g. Ortho Slice properties examples

Orientation **xy**

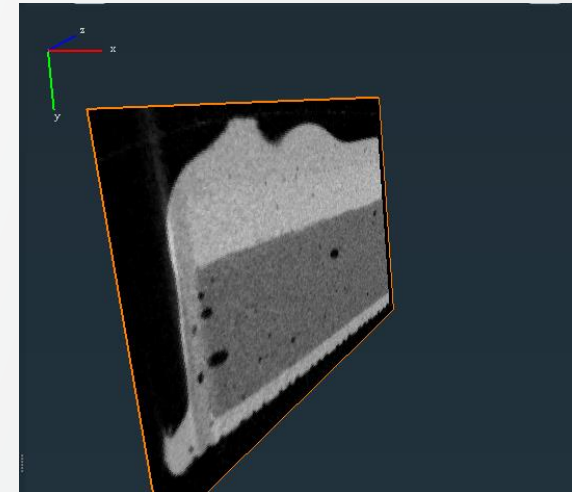
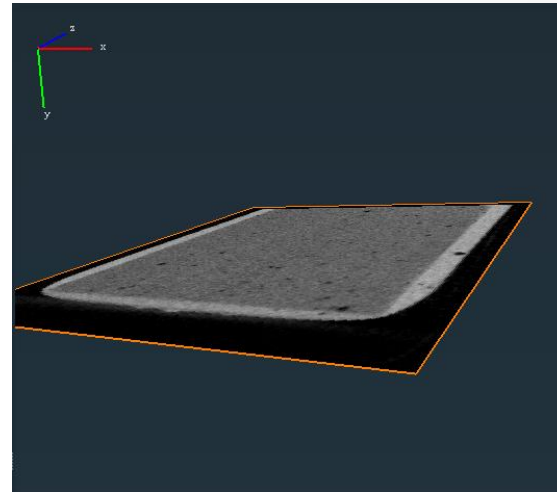
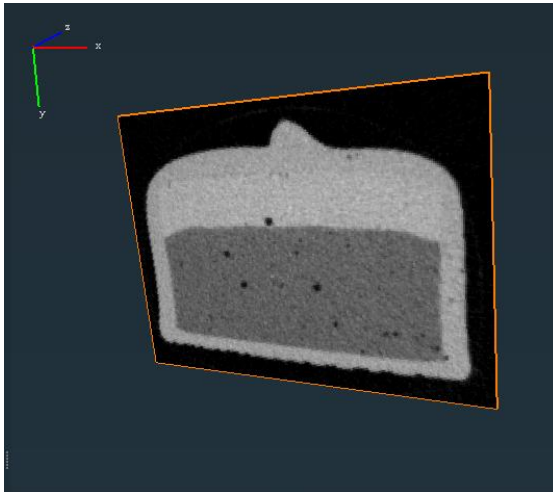
Orientation **xz**

Orientation **yz**

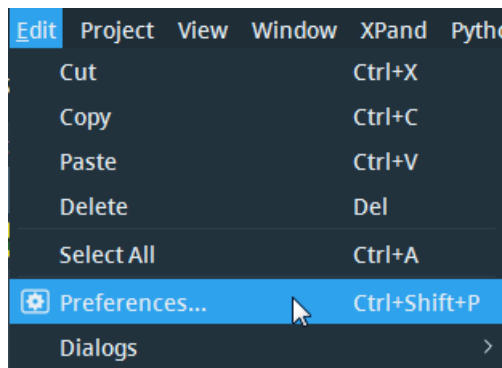
Adjust View on



Adjust View off

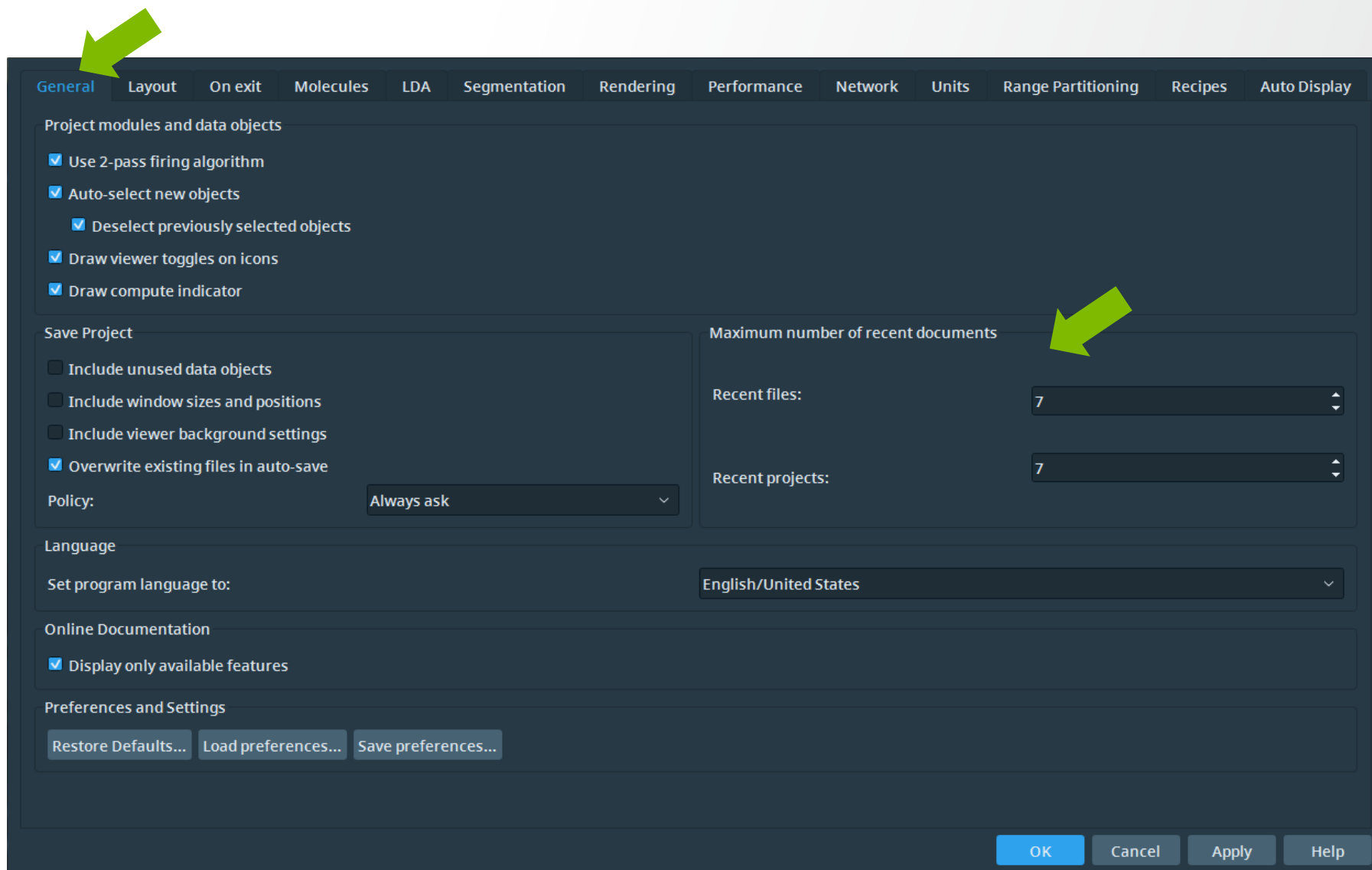


Setting preferences – part 1



Preference setting e.g.:

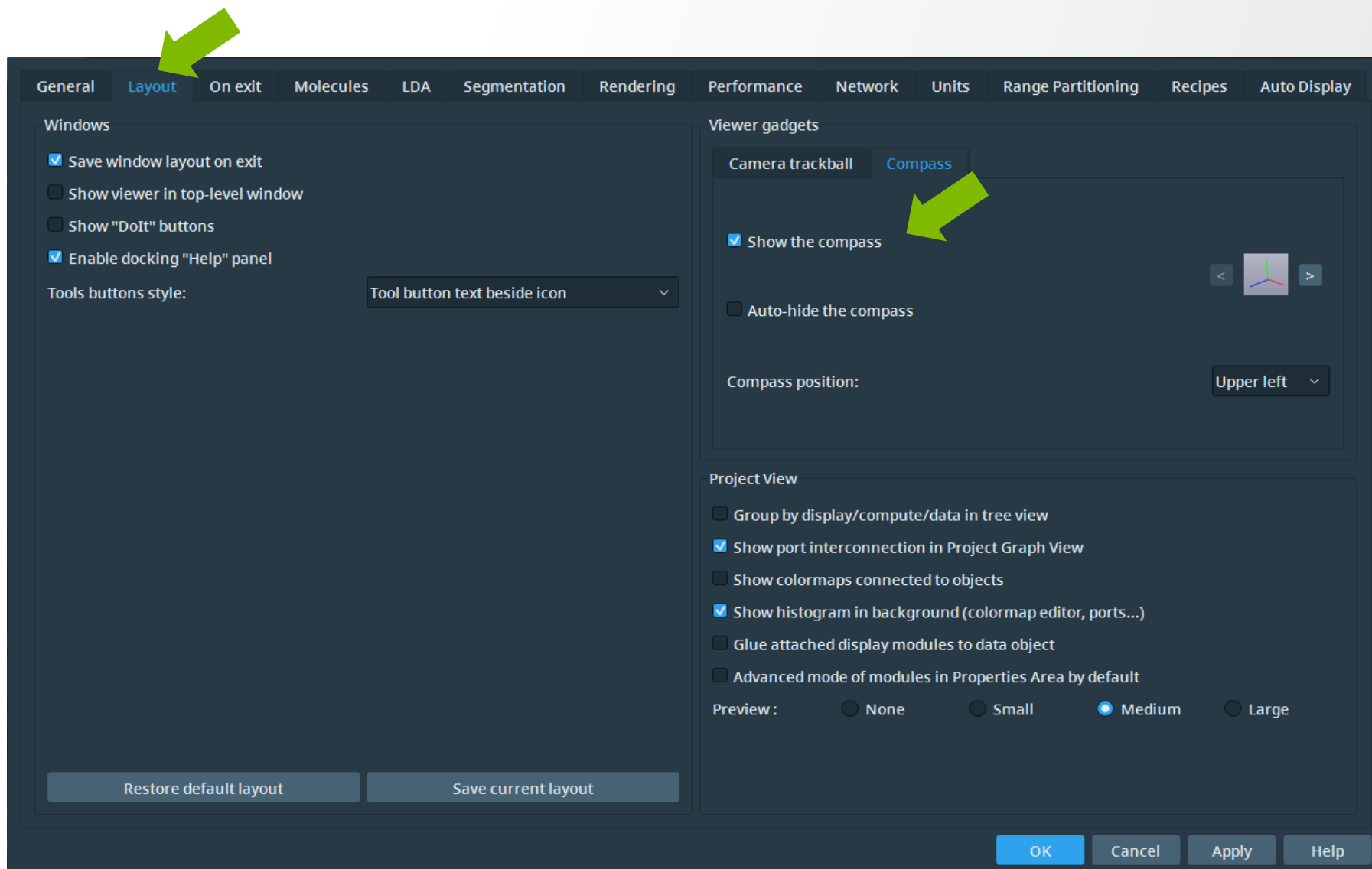
- Set the number of recent files and projects displayed on start page



Setting preferences – part 2

Preference setting e.g.:

- Add compass in the 3D Viewer



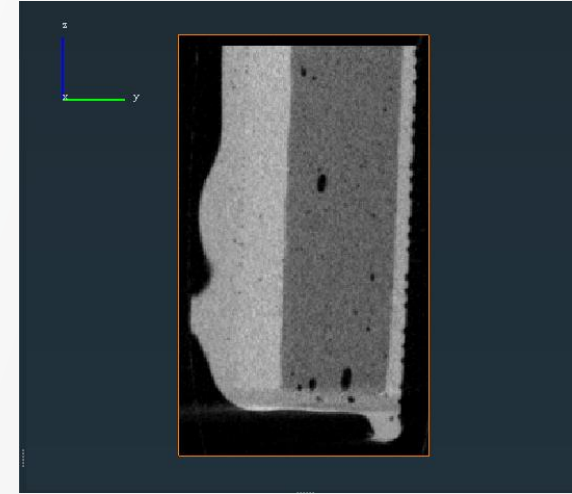
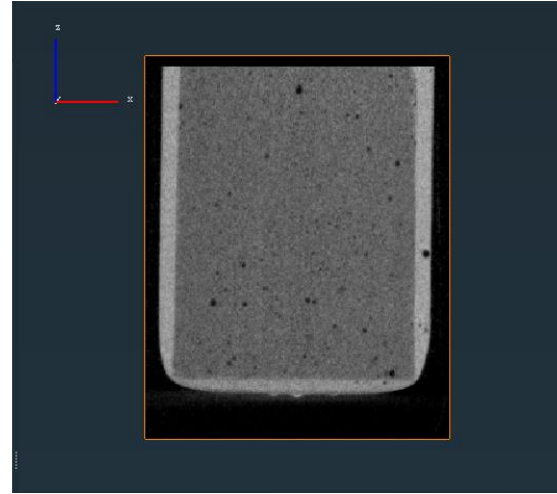
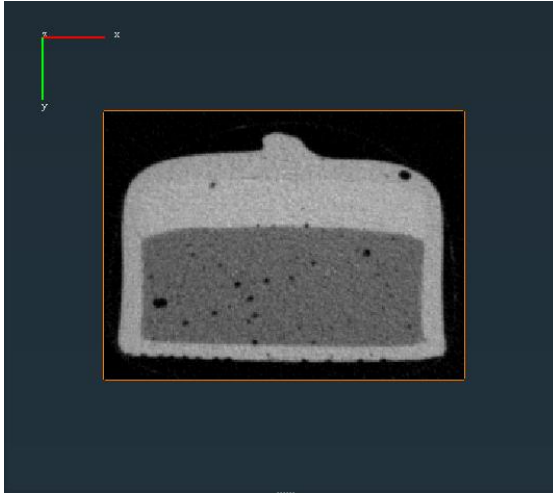
Visualize a Dataset: e.g. Ortho Slice properties examples

Orientation **xy**

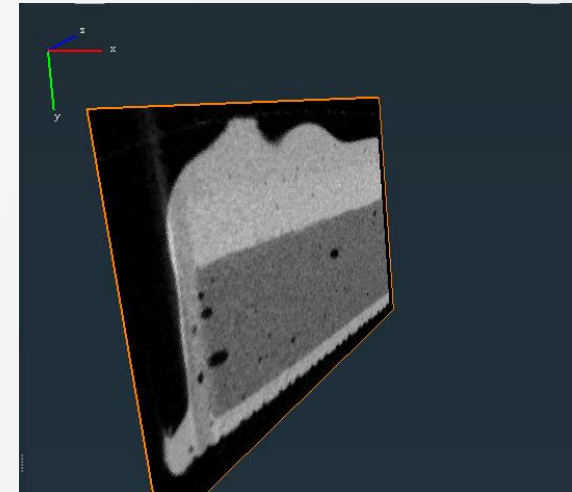
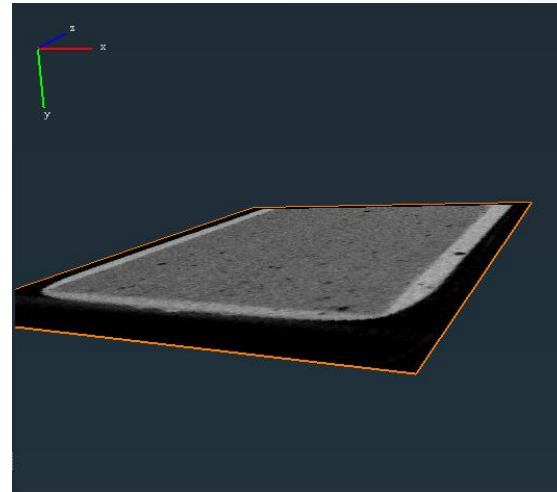
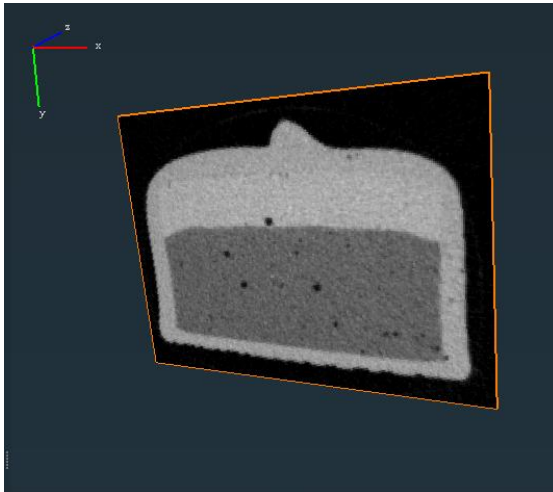
Orientation **xz**

Orientation **yz**

Adjust View on



Adjust View off



Visualization of 2D and 3D data

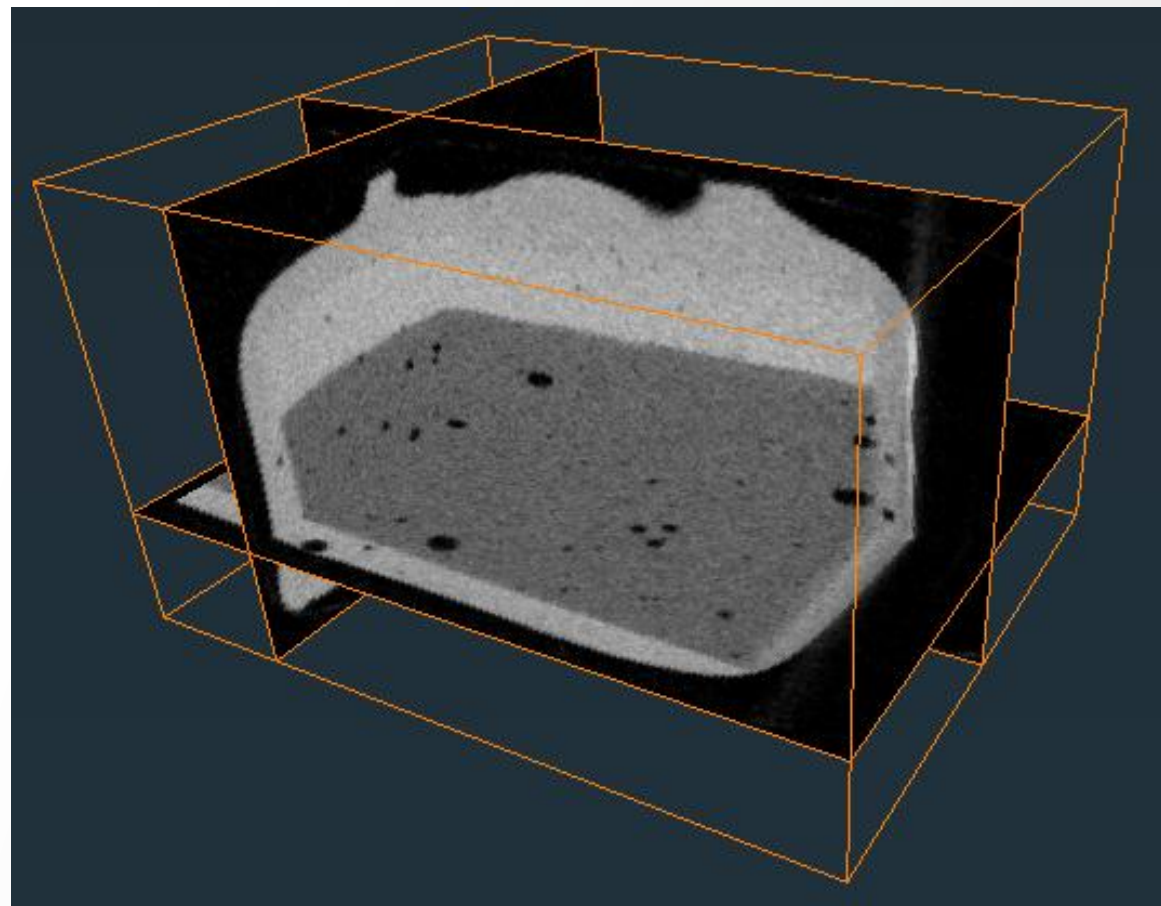
Data visualization: Exercise 1

Setting the orientation of the 2D view

Assemble the necessary modules to create a view like in the screenshot

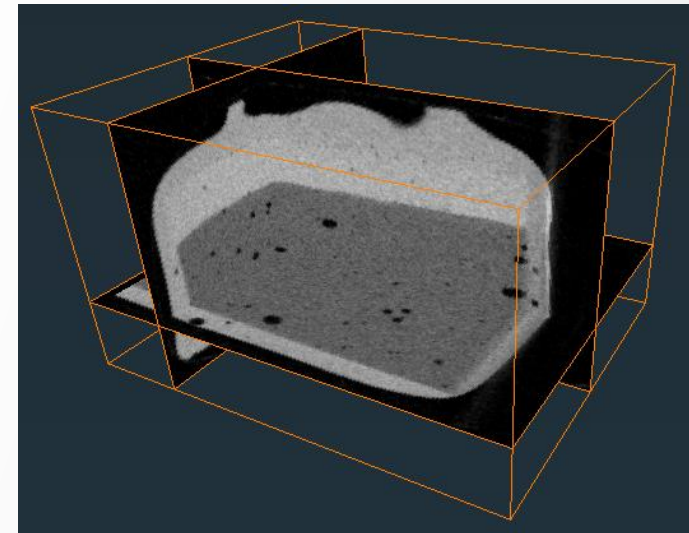
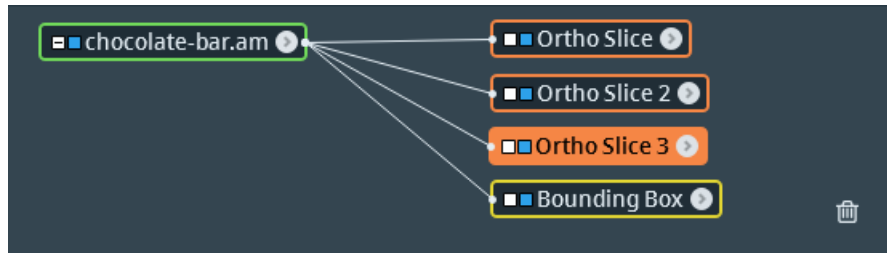
Dataset available at:

- `$INSTALLDIR/data/tutorials/chocolate-bar.am`



Data visualization: exercise 1

Solution



Properties

Ortho Slice	<input checked="" type="radio"/> xy <input type="radio"/> xz <input type="radio"/> yz
Ortho Slice 2	<input type="radio"/> xy <input checked="" type="radio"/> xz <input type="radio"/> yz
Ortho Slice 3	<input type="radio"/> xy <input type="radio"/> xz <input checked="" type="radio"/> yz
Data:	chocolate-bar.am

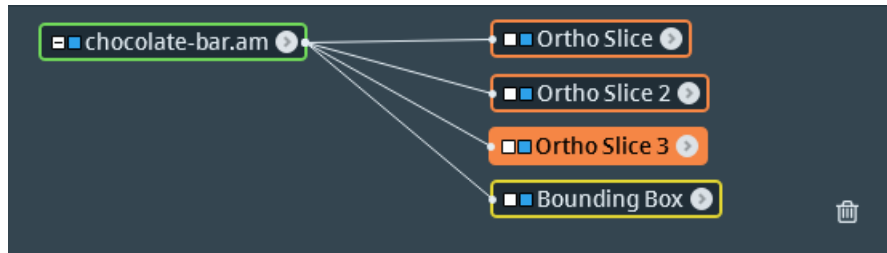
Green arrows point to the 'xy' radio button for 'Ortho Slice', the 'xz' radio button for 'Ortho Slice 2', and the 'yz' radio button for 'Ortho Slice 3'. A green arrow also points to the 'Data' dropdown menu.

Solution:

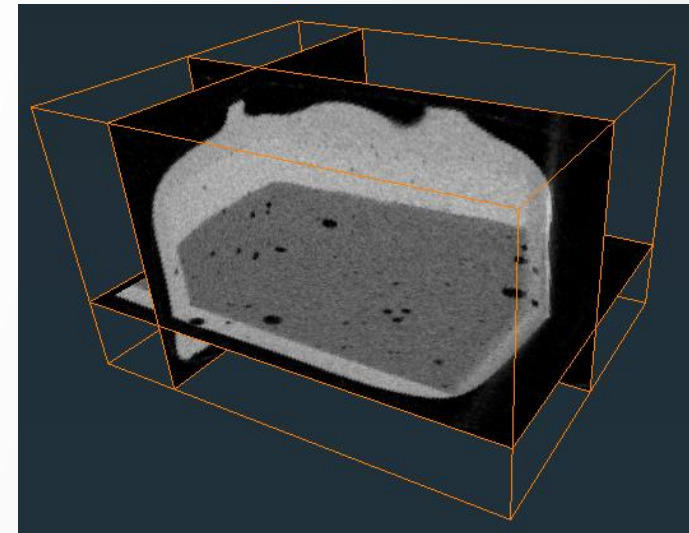
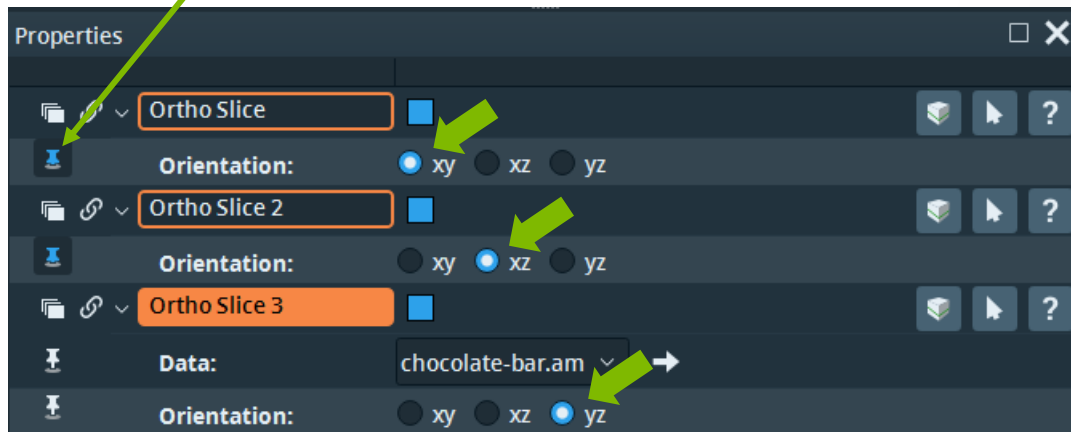
- Connect 3 Ortho Slice modules, each having a different orientation setting
- Note: Multiple modules with different ports settings can be connected to the same data

Data visualization: exercise 1

Tip



Pin button



Tip:

- Module **ports** can be **pinned** by clicking the pin button: **pinned ports** are **always displayed** in the Properties window, even if the module is deselected

Visualize a dataset: e.g. Ortho Slice

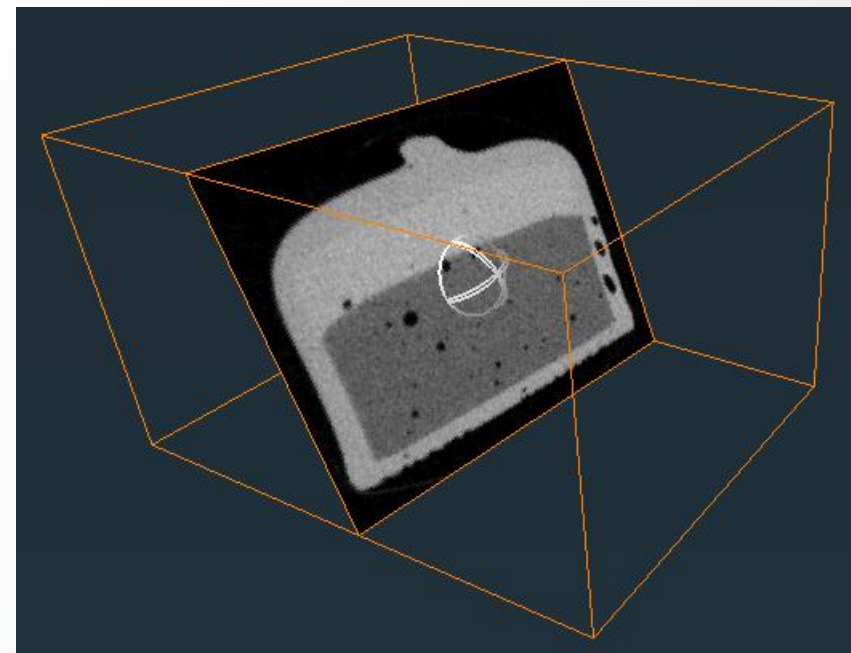
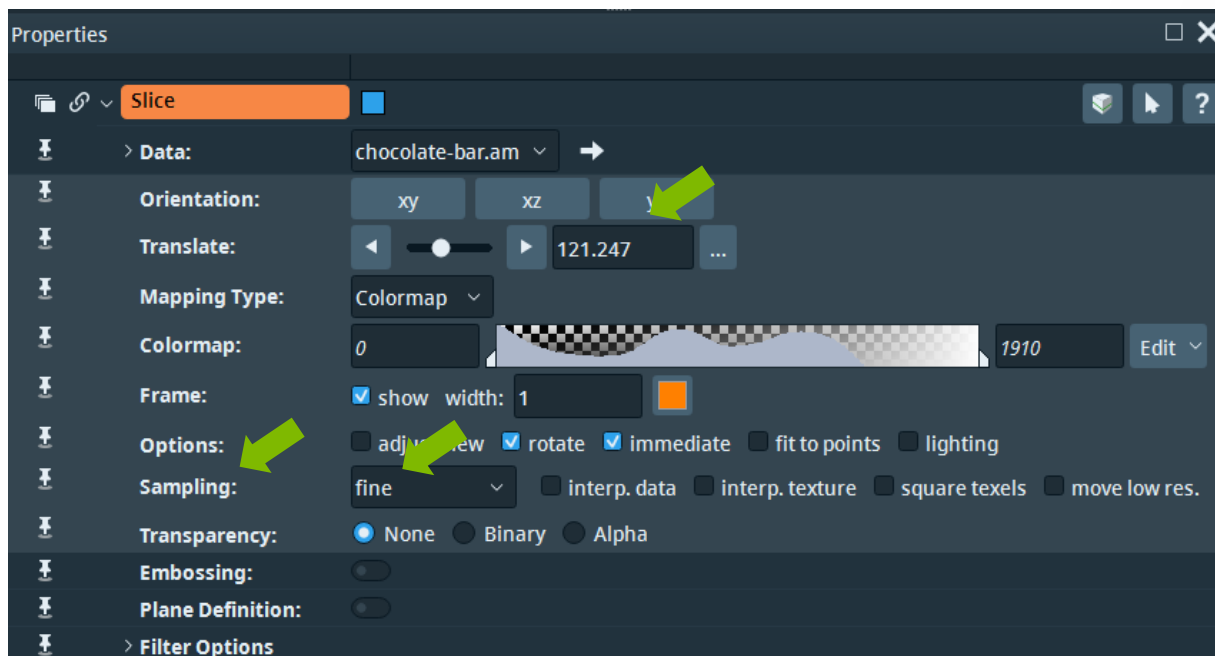
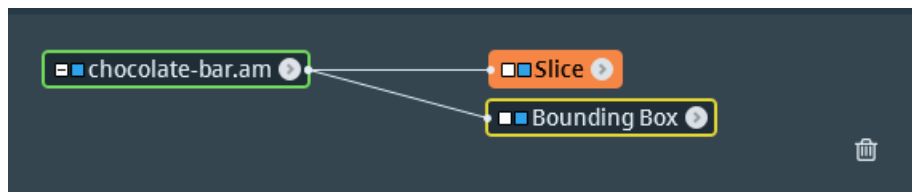
The screenshot displays the software interface with the following components:

- Project View:** Shows a workflow with 'chocolate-bar.am' and 'Ortho Slice' modules. The 'Ortho Slice' module is highlighted in orange.
- Properties Panel:** Configured for the 'Ortho Slice' module.
 - Data:** 'chocolate-bar.am' (highlighted in green)
 - Orientation:** 'xy' (selected)
 - Slice Number:** 147
 - Mapping Type:** 'Colormap'
 - Colormap:** Range from 0 to 1910 with a grayscale preview.
 - Options:** 'adjust view' is checked; 'bilinear view' and 'lighting' are unchecked.
 - Frame:** 'show width' is checked, set to 1.
- 3D Visualization:** A grayscale slice of a chocolate bar is shown in the center of the interface.
- Bottom Bar:** Includes 'Ready', 'Stop', 'MEMORY USAGE' (34%), and a refresh icon.

- Ortho Slice connects Automatically if **Auto Display** is on
- Can otherwise be **created** like any other module
- A dataset is displayed in the viewer only if it has a **visualization module** attached
- Check that **visibility** is **turned on** (e.g. workflow with multiple data)

2D visualization with Slice

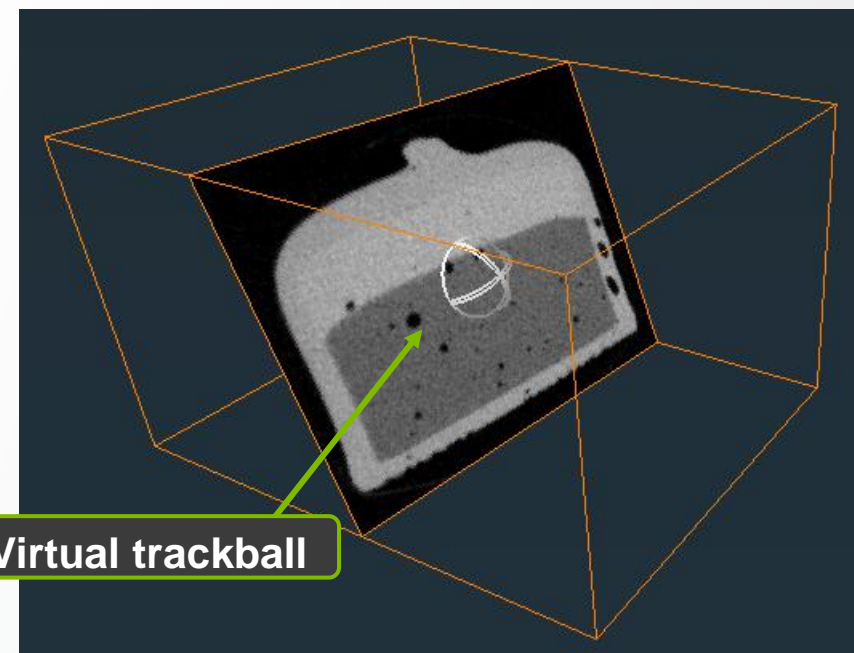
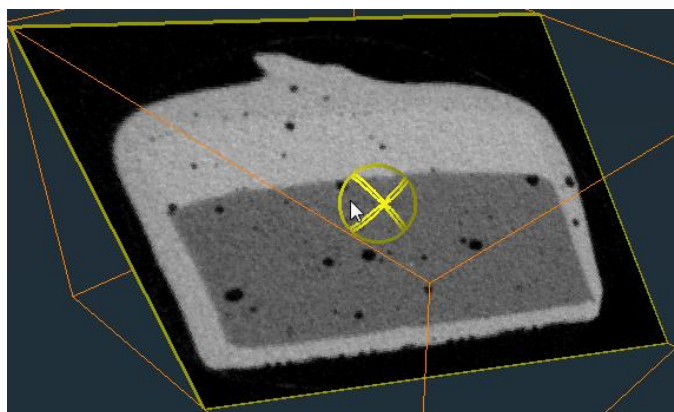
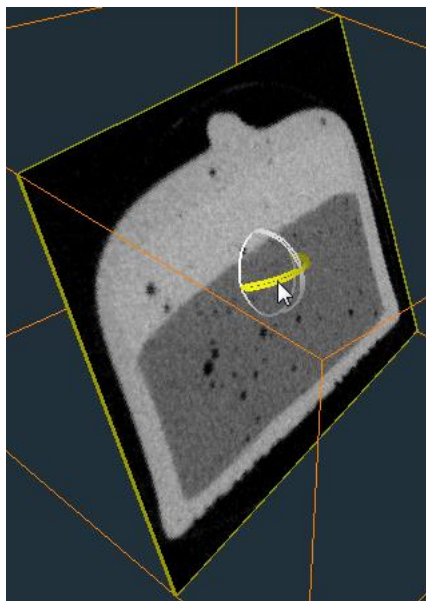
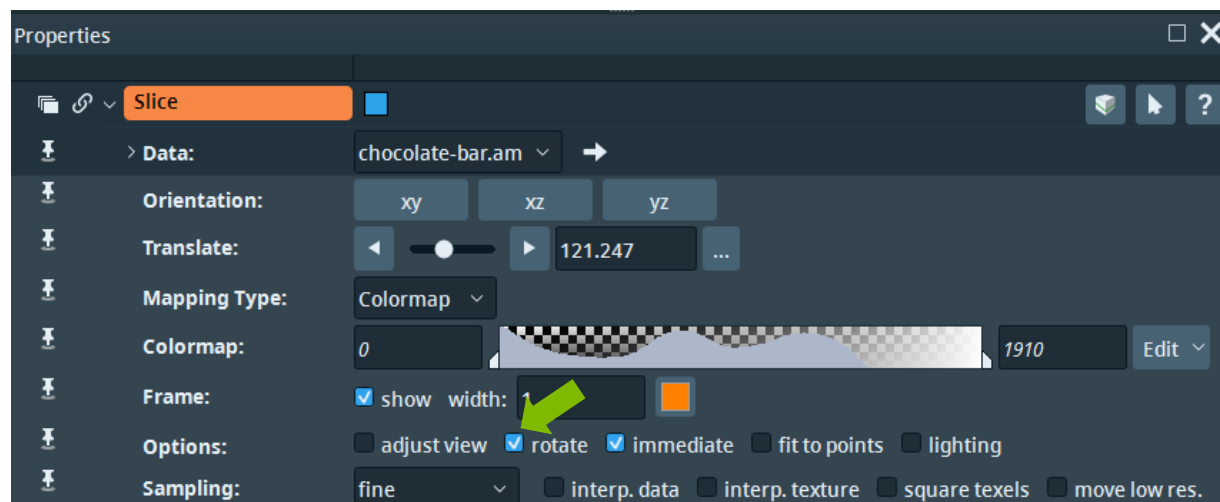
Slice: visualize arbitrarily oriented slices in a volume



Slice – interpolation:

- Not necessarily axis-aligned, interpolation is necessary for reconstruction
- Interpolation can be tuned from Sample ports
 - Different sampling resolutions (fine, coarse, etc.) are available in the drop-down menu.
- Sample ports – no effect if the slice is axis-aligned.

2D visualization with Slice



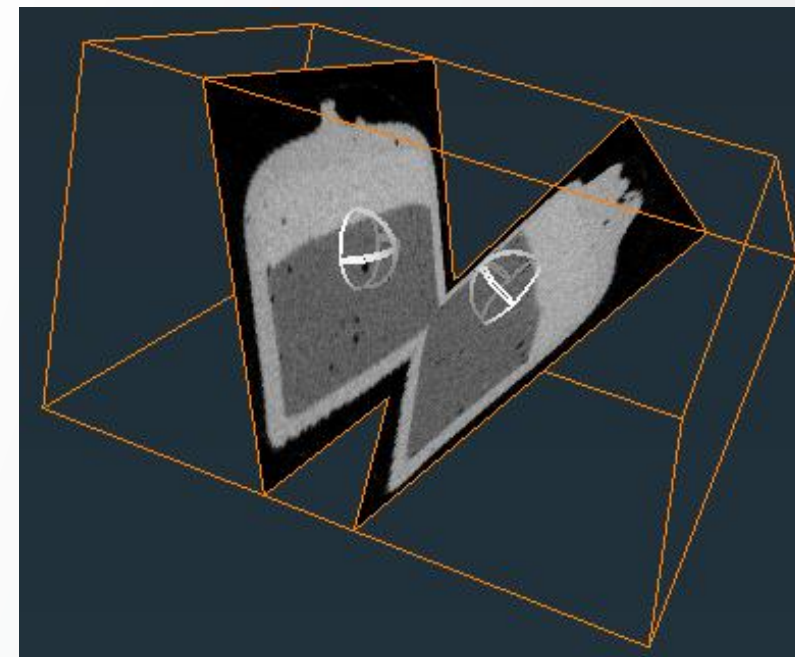
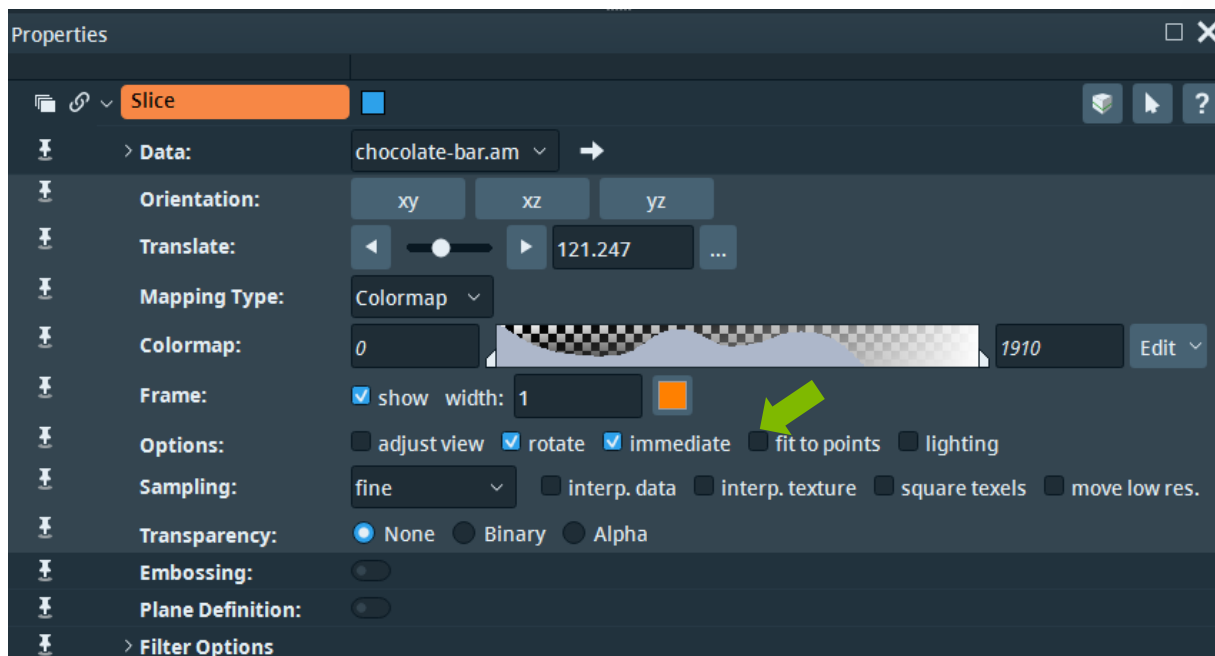
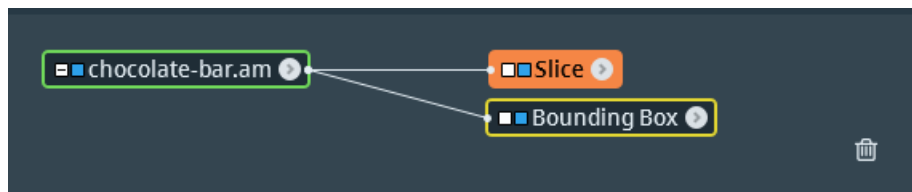
Virtual trackball

Slice – rotate:

- Activate **virtual trackball**: Press [Tab] or select “rotate” (from Options)
- Hold the left mouse button in interactive mode:
 - Click inside the white lines of a trackball axis => **rotate along** the respective **axis**
 - Click outside the trackball axes => **rotate in all directions**

2D visualization with Slice

Slice: visualize arbitrarily oriented slices in a volume

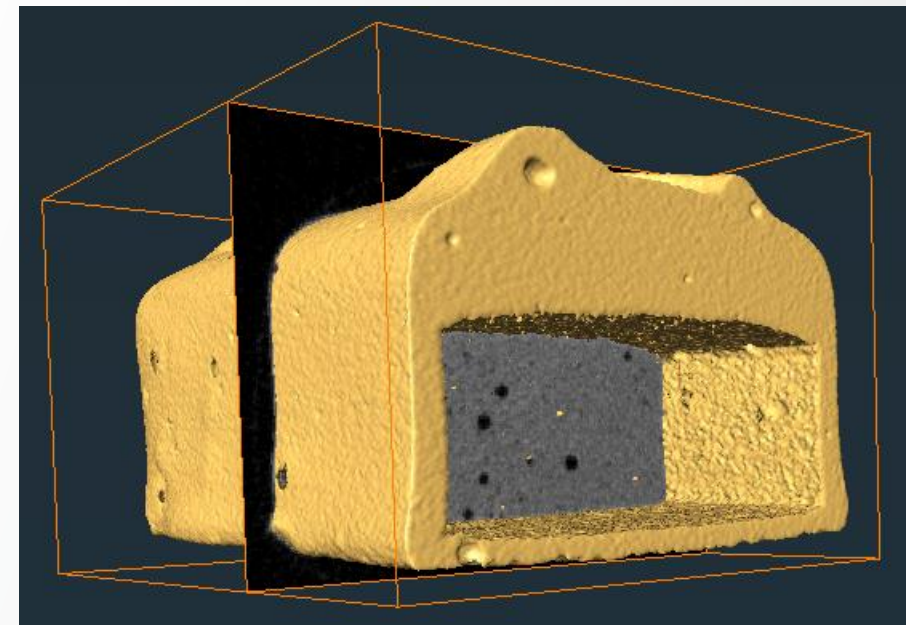
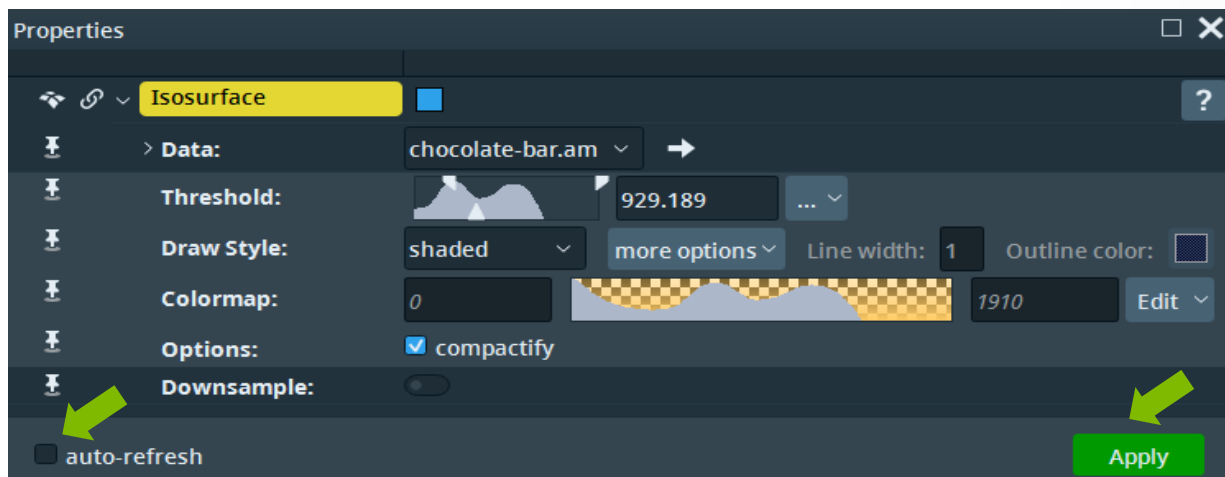
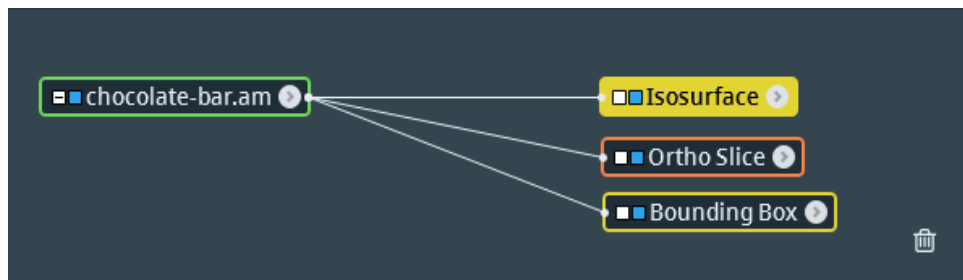


Slice – defining a plane:

- Select “fit to points” (from Options)
- Click on 3 different points inside the object
Press [Esc] to activate Interact mode.
- After clicking 3 points, “fit to points” is automatically disabled.

3D visualization with Isosurface

Isosurface: visualization of surfaces of same value

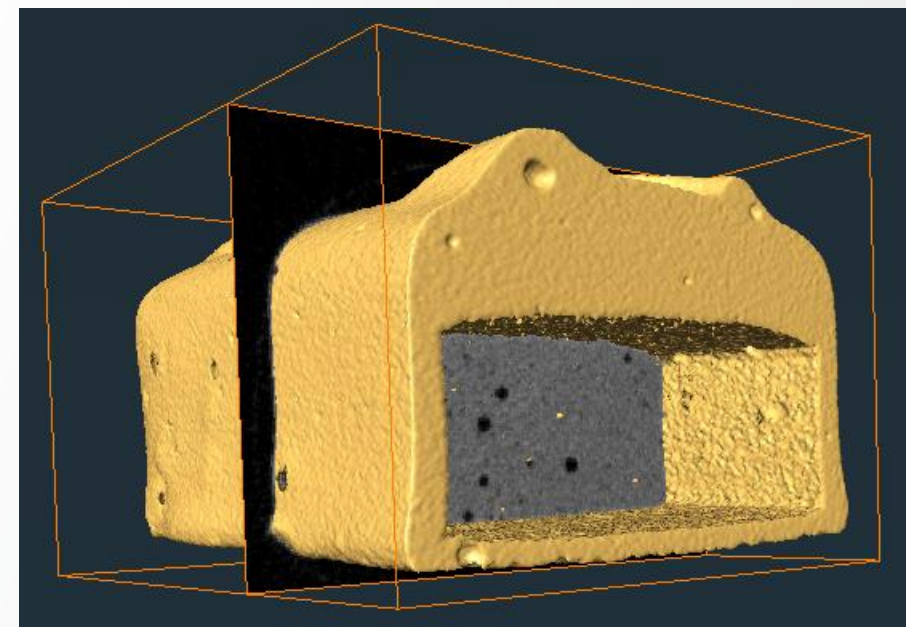
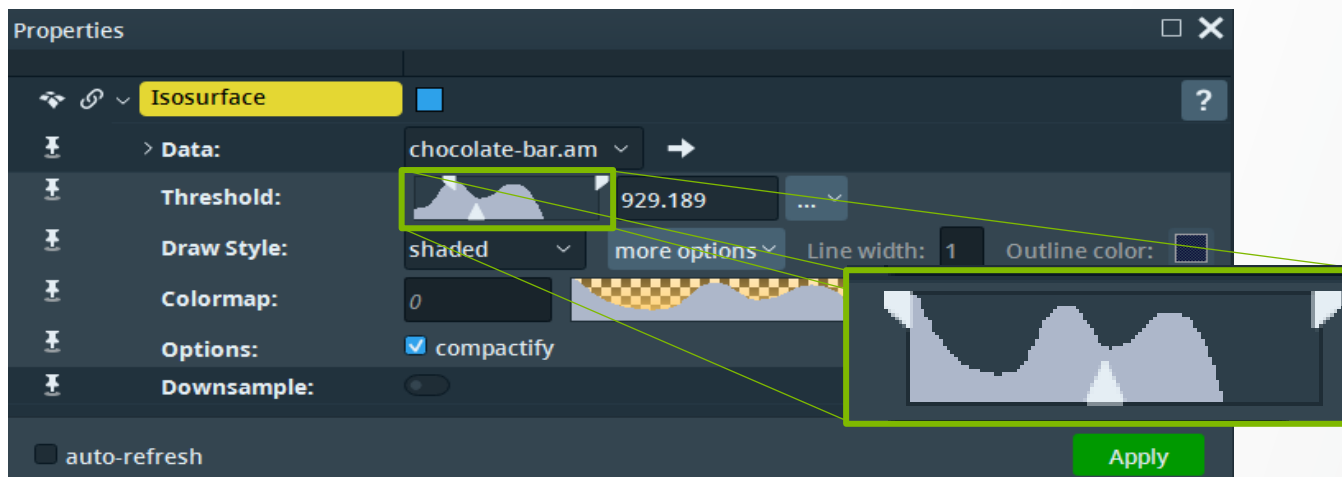
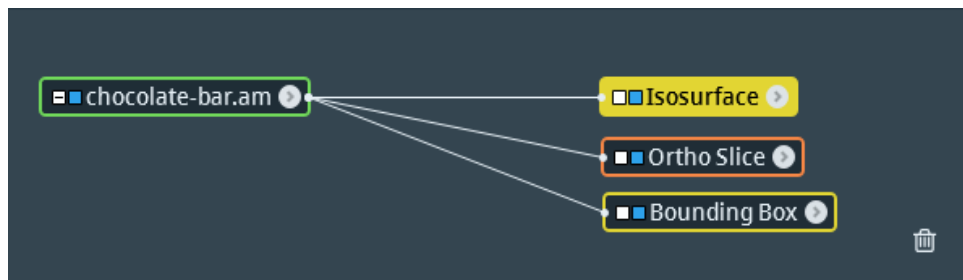


Isosurface – **visualization module** that requires **processing**. For launching the processing:

- Press the **Apply button**
- Check **auto-refresh** (use with caution)

3D visualization with Isosurface

Isosurface: visualization of constant value surfaces



A **threshold value** is necessary for computing the Iso-surface:

- set by default from data histogram
- can be manually adjusted (bottom slider)

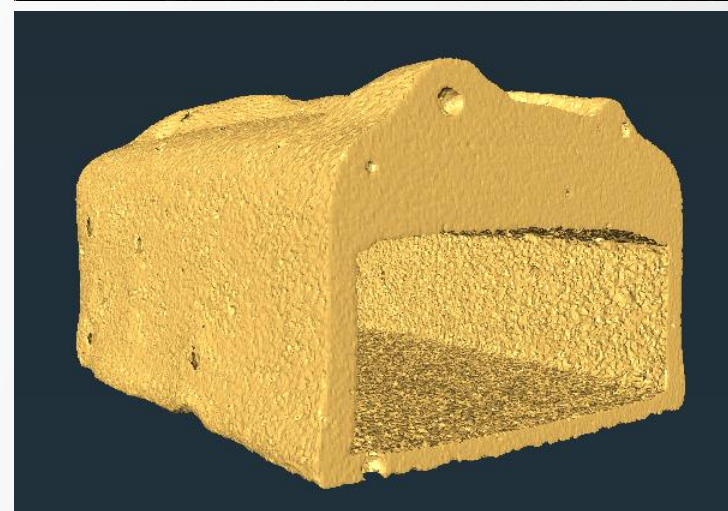
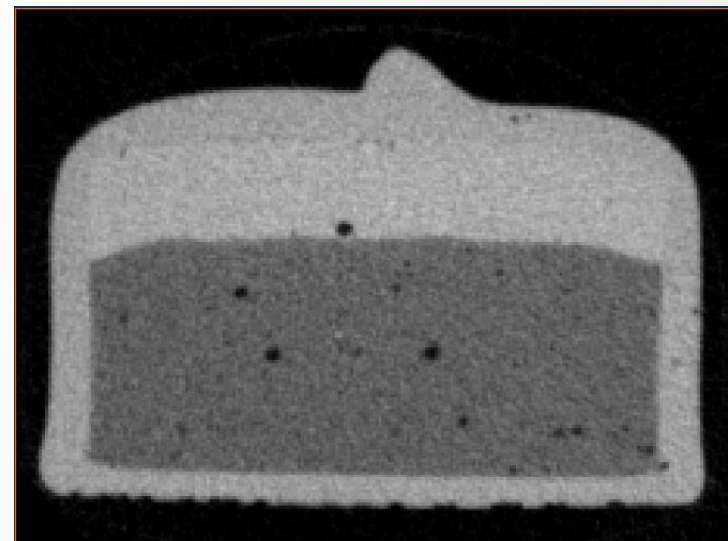
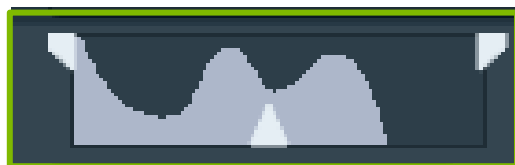
Top sliders – zoom on the histogram

3D visualization with Isosurface

Histogram Thresholding

- Histogram – the distribution of voxel intensity values
- Can be computed by “Histogram” module
- Its shape is informative for thresholding a dataset
- In the case of chocolate bar data, the histogram has 3 lobes for:
 - background and porosities
 - for the “mousse” (inside)
 - for the chocolate and caramel (outer layers)

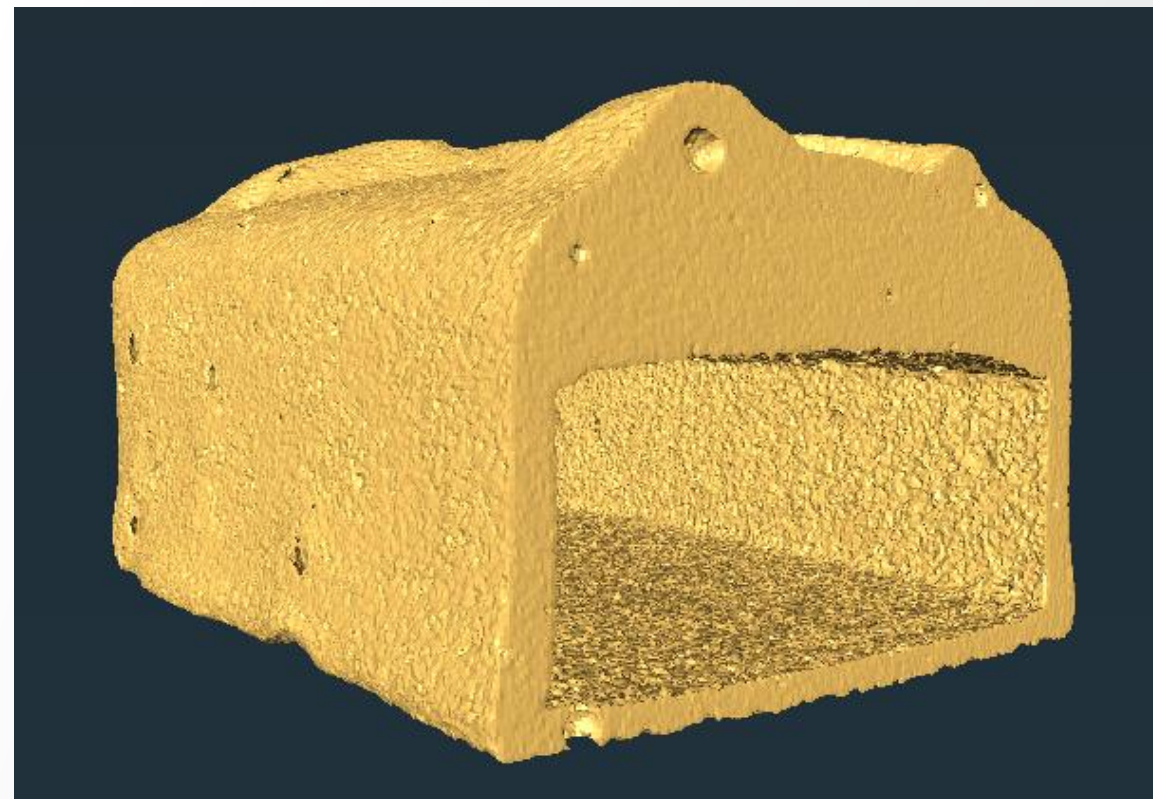
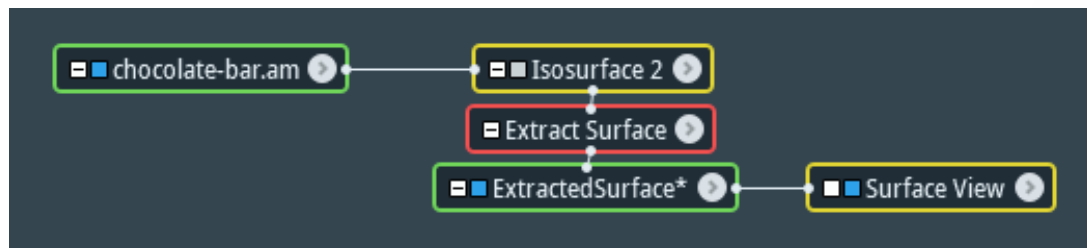
By setting a histogram **threshold value** as indicated below, The outer chocolate bar layers will be selected, as they correspond to the third histogram lobe (highest intensity values).



3D visualization with Isosurface

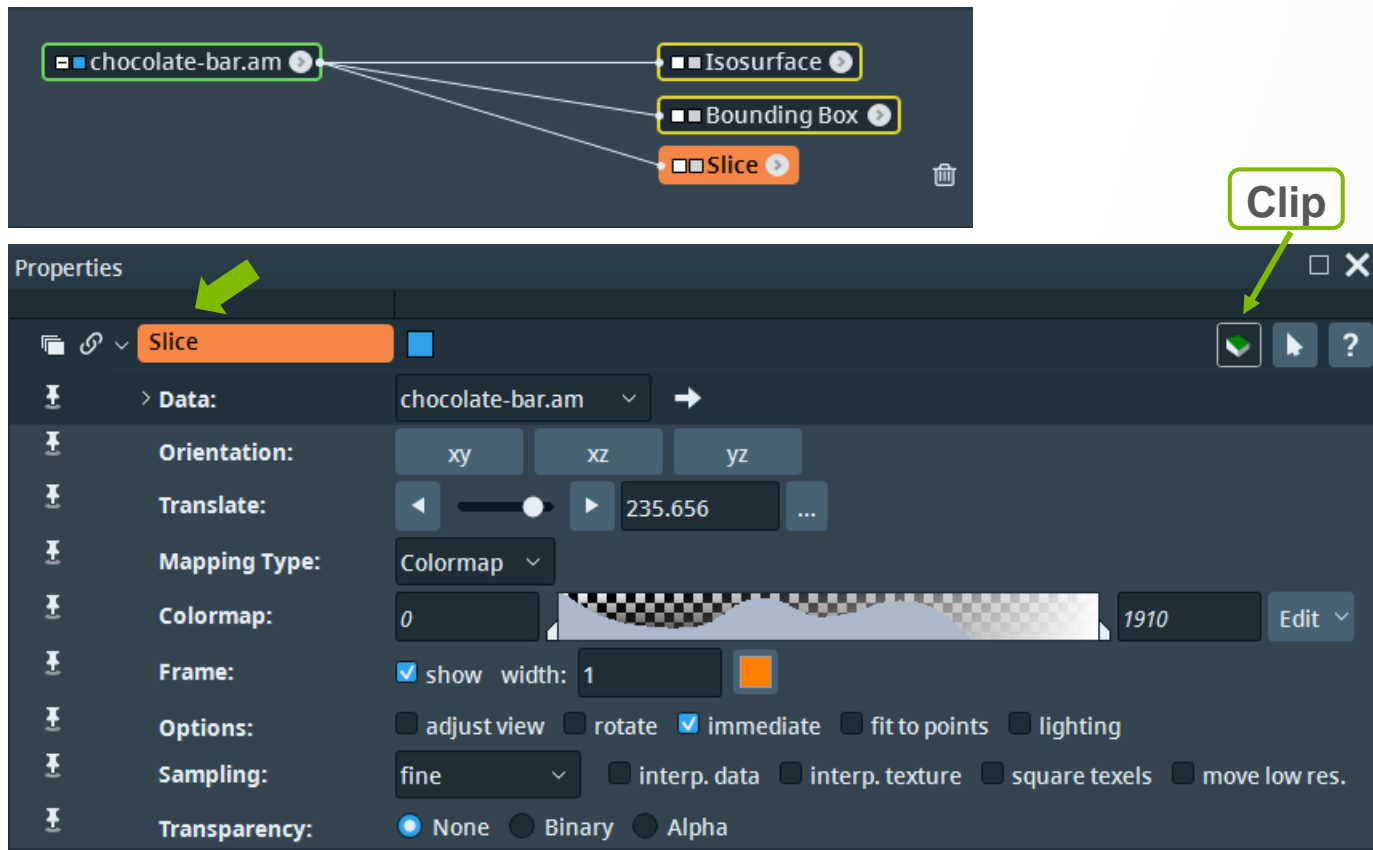
Isosurface:

- For generate the surface computed by Isosurface, use “**Extract Surface**” module.
- For visualizing the generated surface, use “**Surface View**” module.

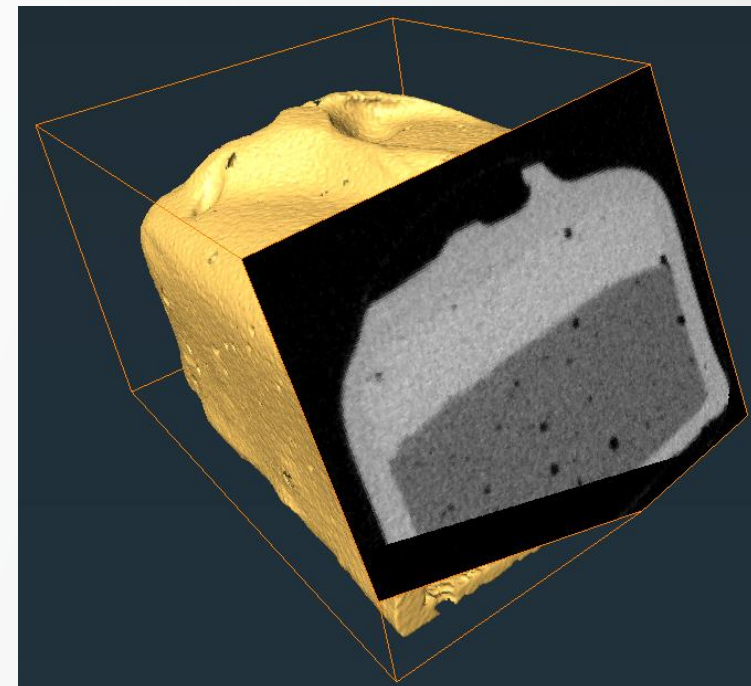


Planar visualization modules - clipping

Planar visualization (orange) modules can be used for clipping. Clipping applies to all the objects that have the visibility on.



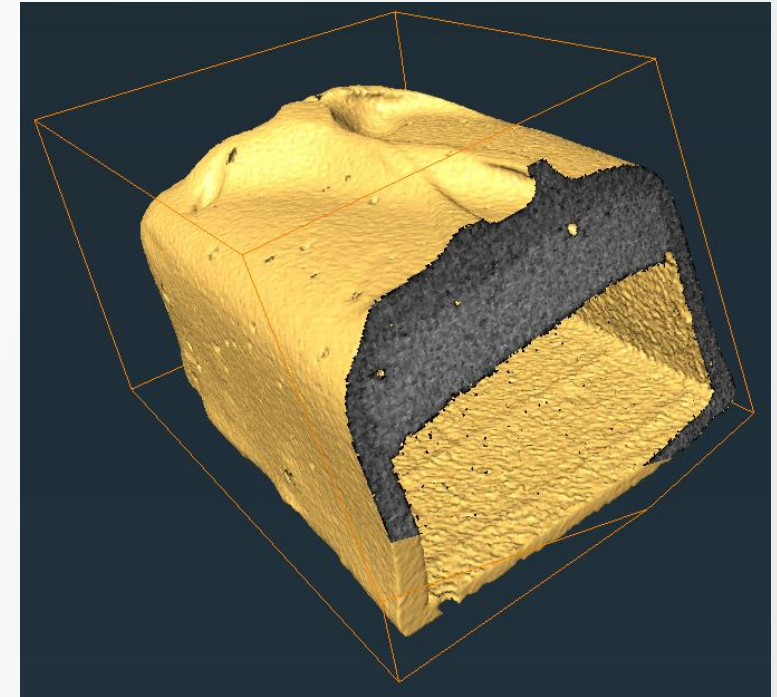
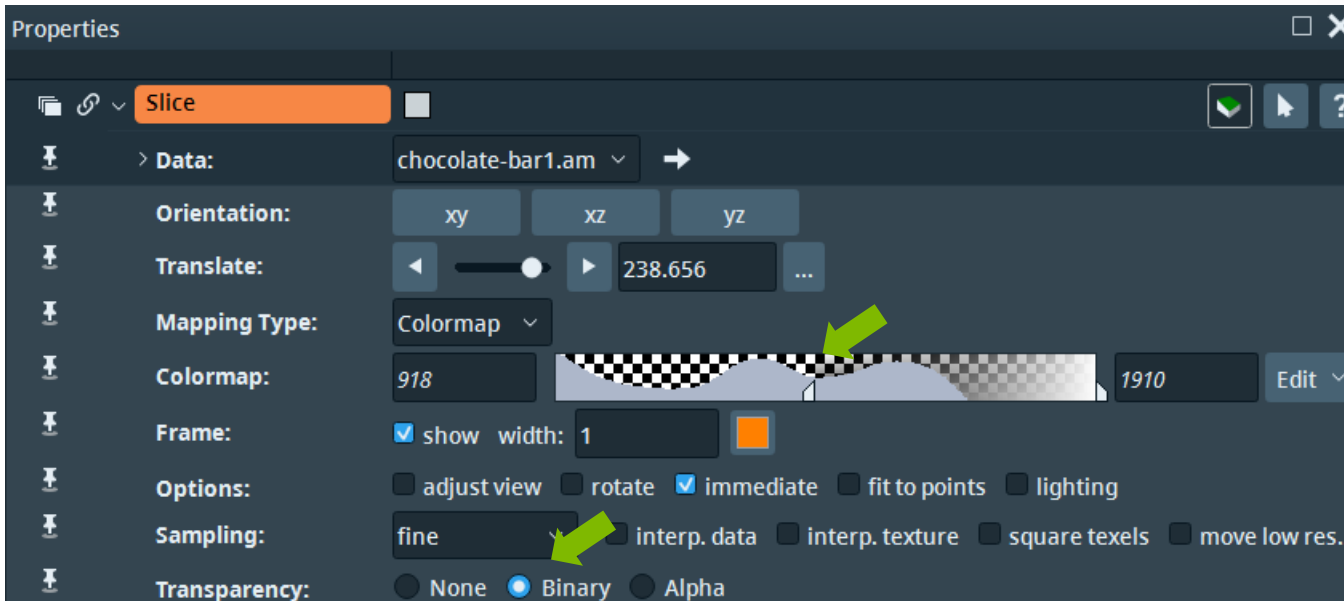
The screenshot shows the software interface. At the top, a tree view displays a hierarchy: 'chocolate-bar.am' (highlighted in green) is the parent of 'Isosurface', 'Bounding Box', and 'Slice' (highlighted in orange). Below this is the 'Properties' panel for the 'Slice' module. The 'Data' field is set to 'chocolate-bar.am'. The 'Orientation' is set to 'xy'. The 'Translate' field has a value of 235.656. The 'Mapping Type' is 'Colormap'. The 'Colormap' is set to '0'. The 'Frame' section has 'show width' checked and set to 1. The 'Options' section includes 'adjust view', 'rotate', 'immediate' (checked), 'fit to points', and 'lighting'. The 'Sampling' section includes 'fine', 'interp. data', 'interp. texture', 'square texels', and 'move low res.'. The 'Transparency' section includes 'None' (selected), 'Binary', and 'Alpha'. A green arrow points to the 'Slice' module in the tree, and another green arrow points to the 'Clip' icon (a green checkmark) in the 'Properties' panel.



Clipping:

- Define the clipping plane by e.g. Slice
- Click on the “Clip” icon – clip on one side of the object
- Click again – disable clipping
- Click again – clip on the other side

Planar visualization modules - clipping



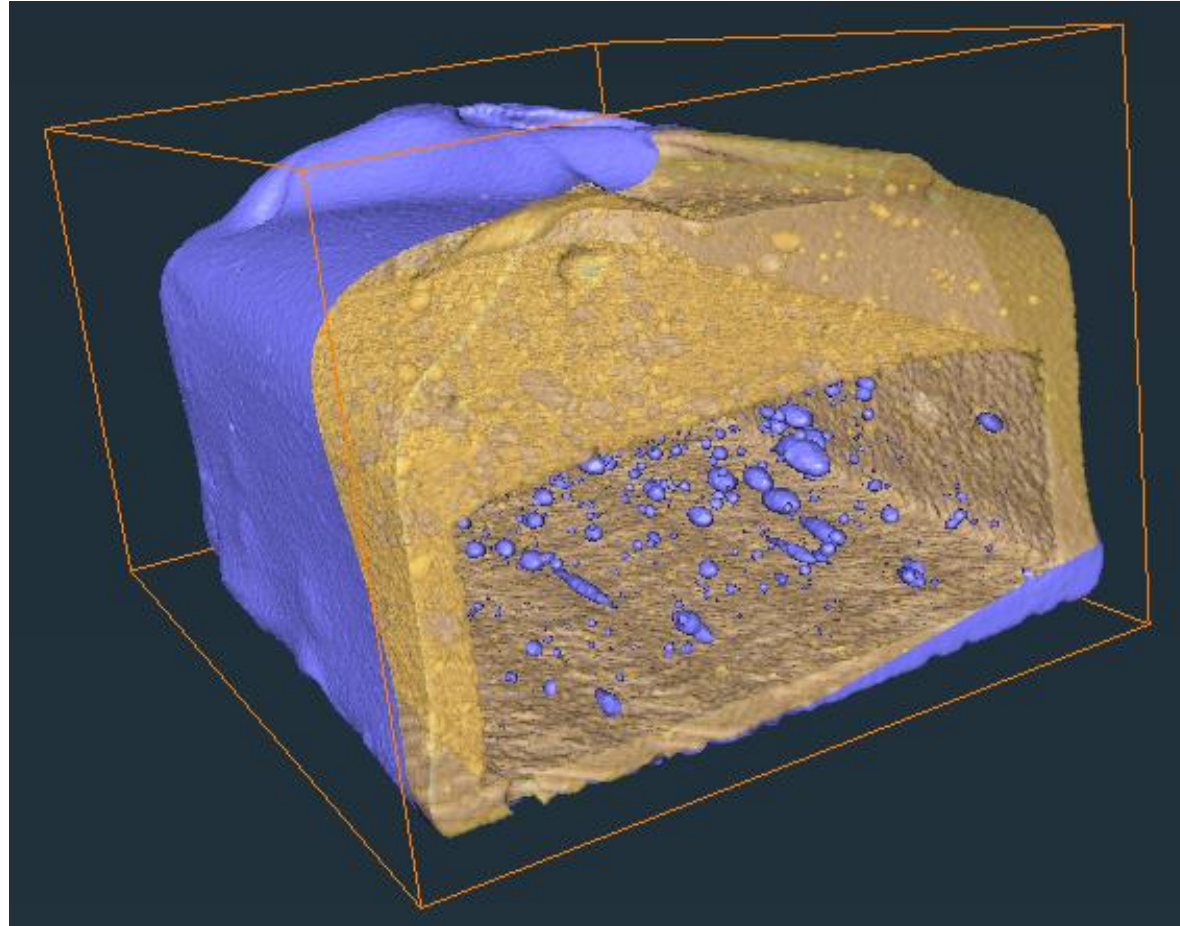
Setting Slice transparency:

- Choose **Binary** mode (from Transparency) – regions of voxel intensity values outside the colormap range are fully transparent while others are fully opaque.
- Adjust the colormap range to obtain the view in the example above.

Data visualization: exercise 2

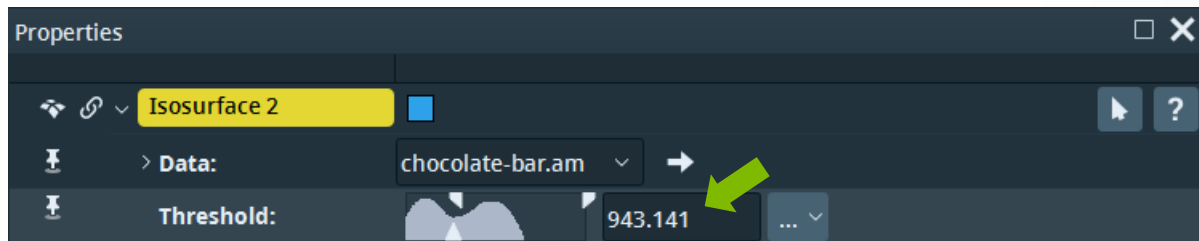
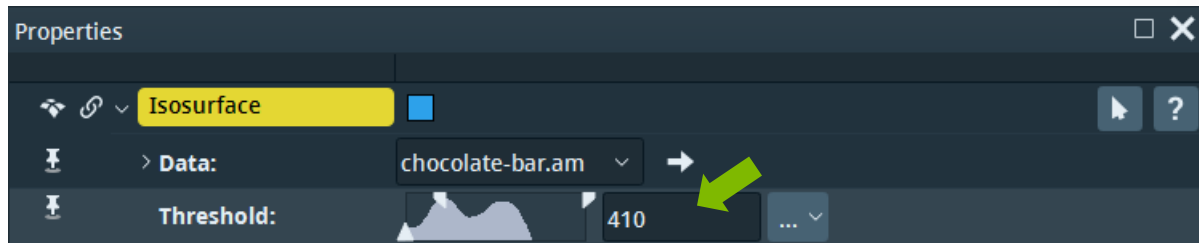
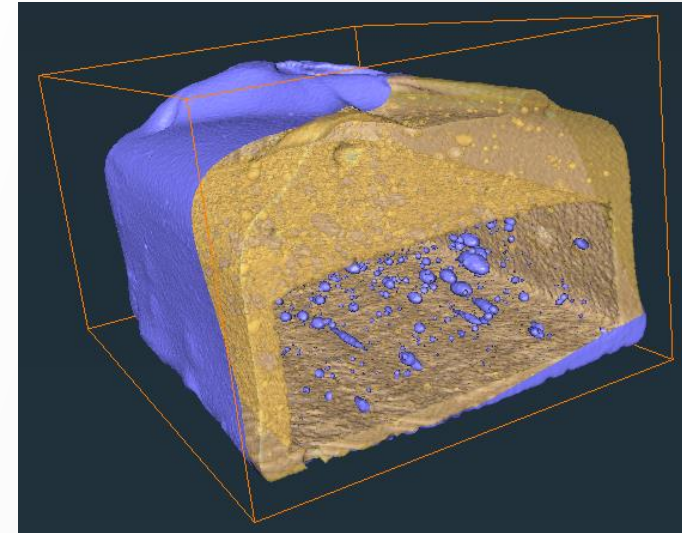
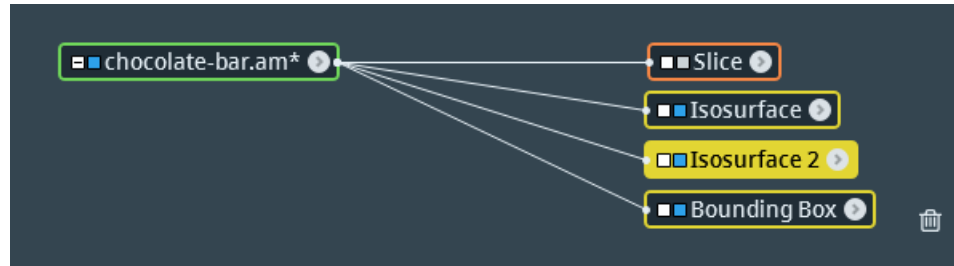
Clipping volumes and setting transparency

Assemble the necessary modules to create a similar view:



Data visualization: exercise 2

Solution – Step 1

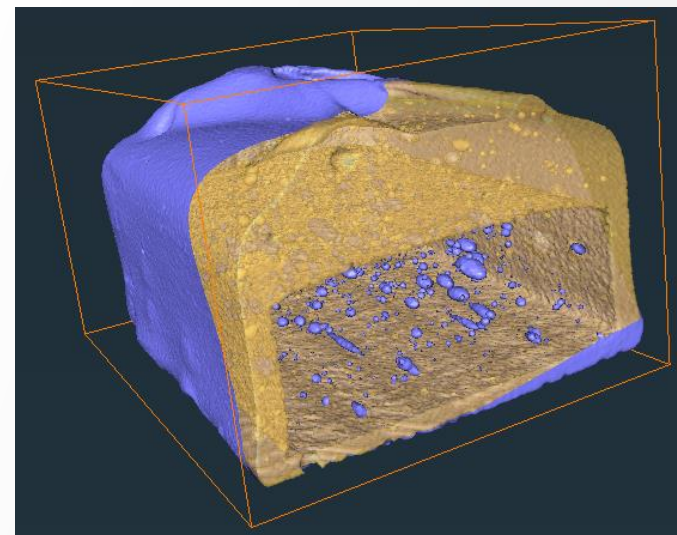
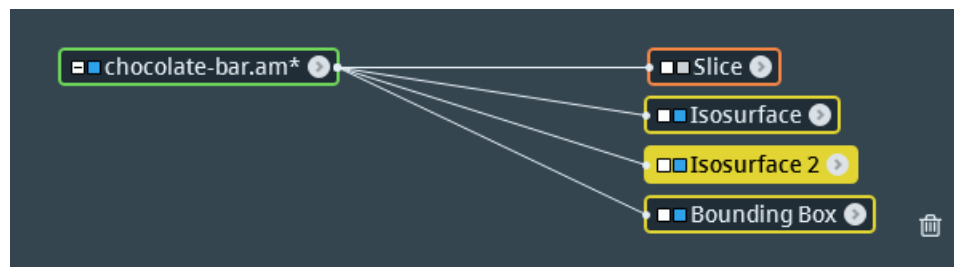


Generate 2 isosurfaces for two thresholds:

- Low threshold: ~ 410
- High threshold: ~ 940

Data visualization: exercise 2

Solution – Step 2



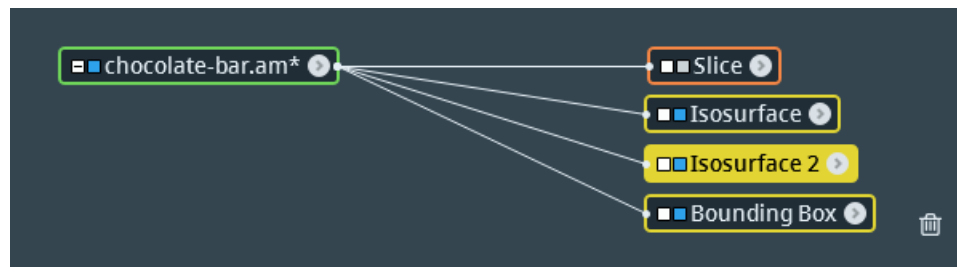
Clip the 1st Isosurface with Slice:

- All visible modules are clipped => the visibility of all other modules except the 1st Isosurface should be turned off.
Tip: Select 1st Isosurface and press [h] => only the selected module has the visibility switched on.
- Select the clipping plane with Slice and then clip.

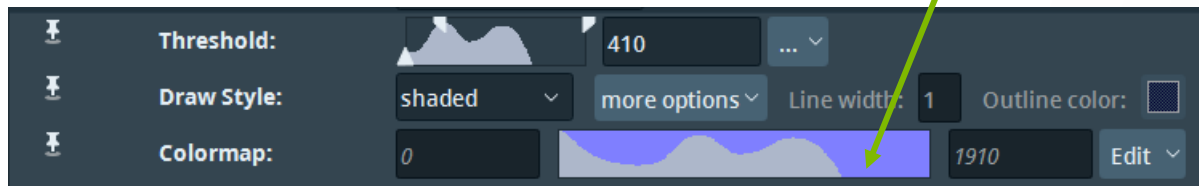
Data visualization: exercise 2

Solution – Step 3

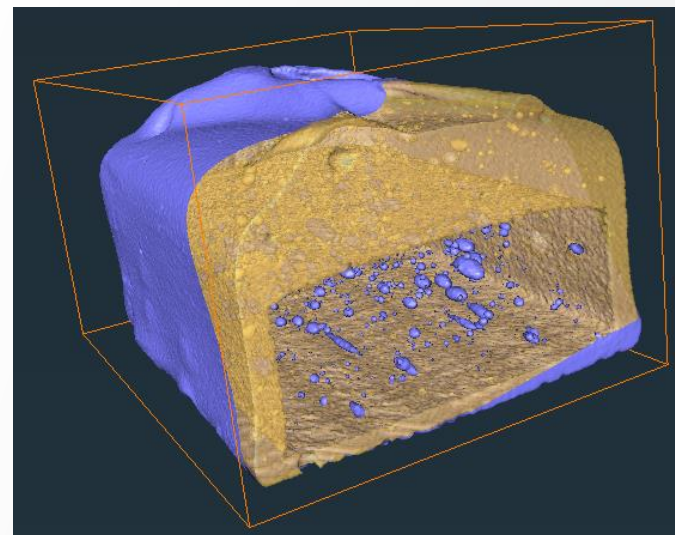
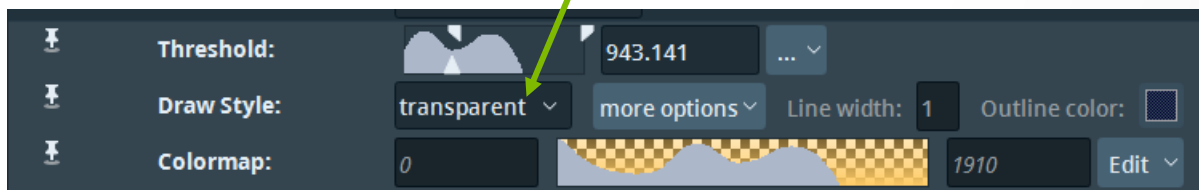
Full solution available at:



Double click to
change color



Set transparency



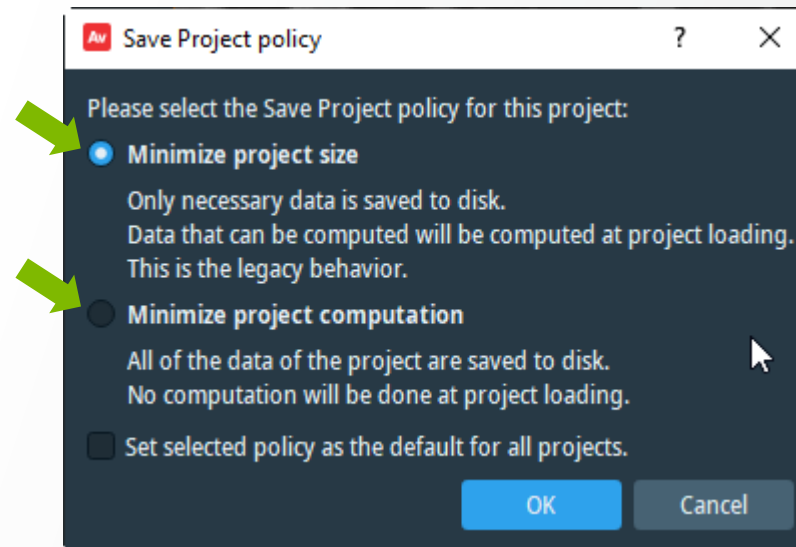
Setting visibility, colors and transparency:

- Turn off the visibility of Slice
- Change the color of the 1st Isosurface: double click on the colormap to pick color
- Set a transparency to the 2nd Isosurface – select “transparent” (“Draw style” port)

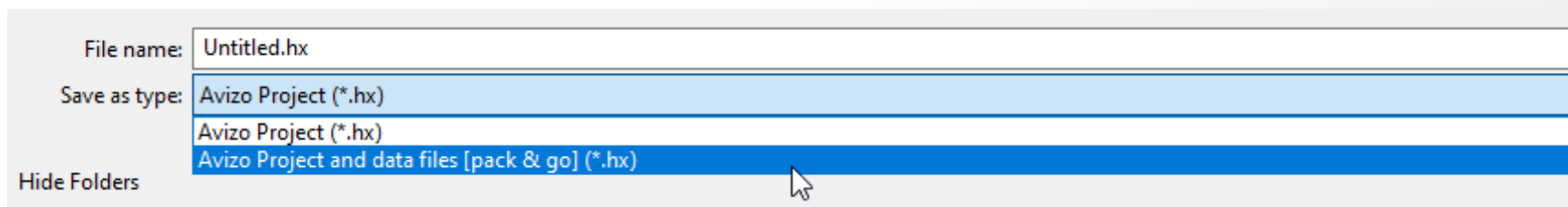
Project save

Saving a project: File > Save Project (As) ...

- Use “**Minimize project computation**” when a module takes a long computation time
- Use “**Minimize project size**” otherwise



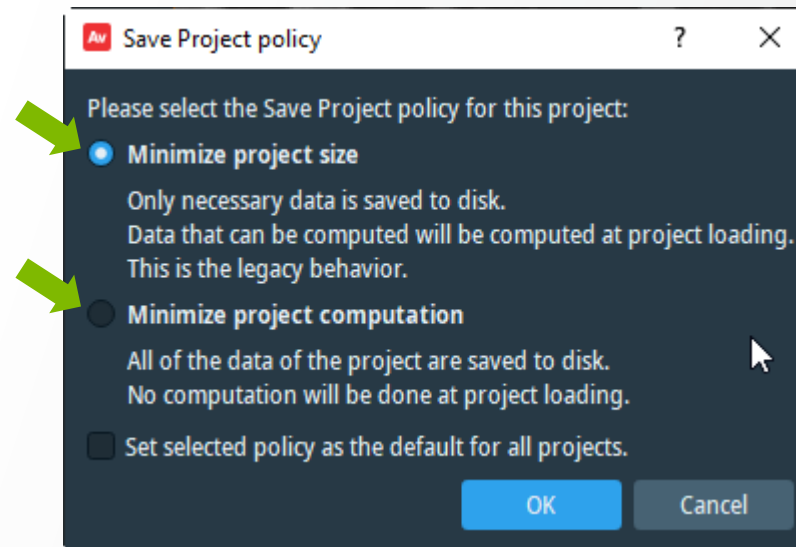
- Use ‘**[pack & go]**’ option if you need to archive or transfer the project to a different computer.
- This will copy the input dataset(s) inside the project folder. Otherwise, these files are only referenced via their path on the disk, and the project will not load if this path is no longer valid.



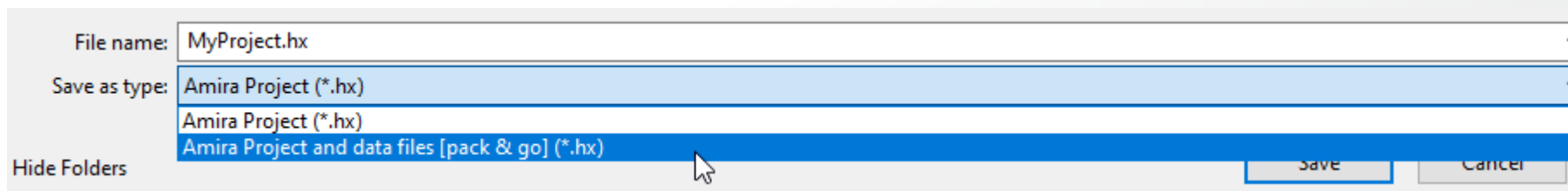
Project save

Saving a project: File > Save Project (As) ...

- Use “Minimize project computation” when a module takes a long computation time
- Use “Minimize project size” otherwise



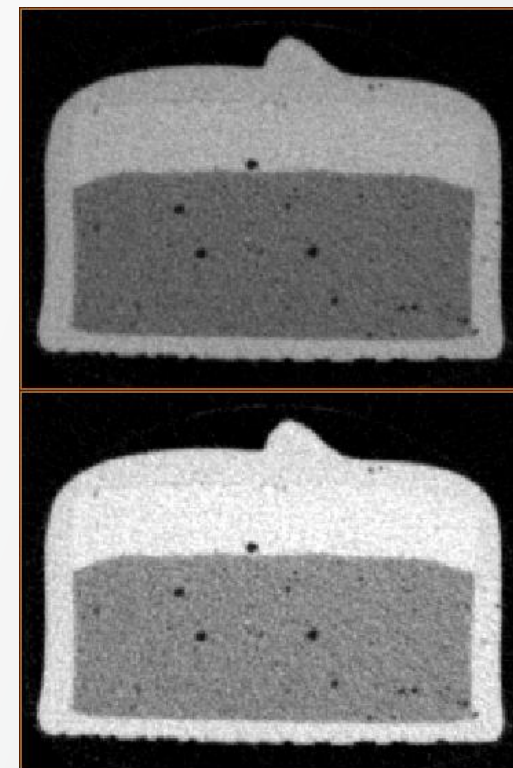
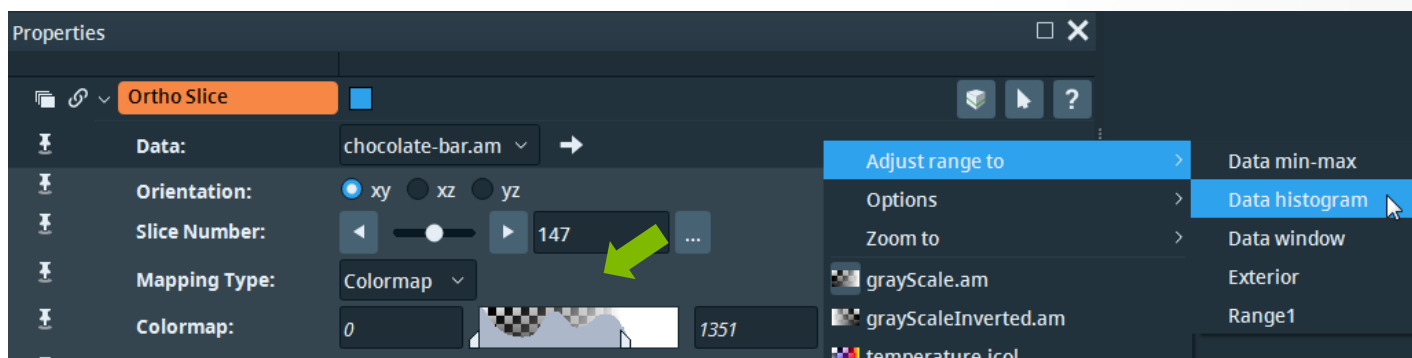
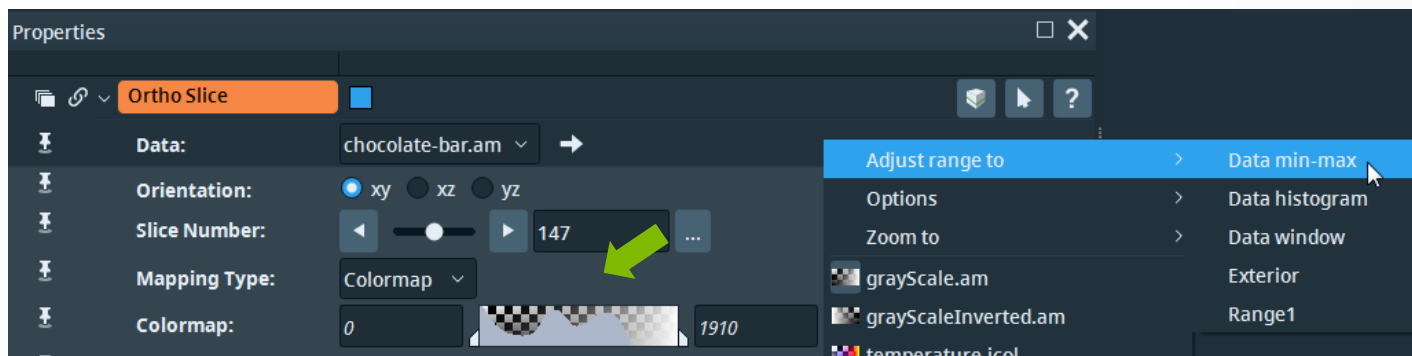
- Use ‘[pack & go]’ option if you need to archive or transfer the project to a different computer.
- This will copy the input dataset(s) inside the project folder. Otherwise, these files are only referenced via their path on the disk, and the project will not load if this path is no longer valid.



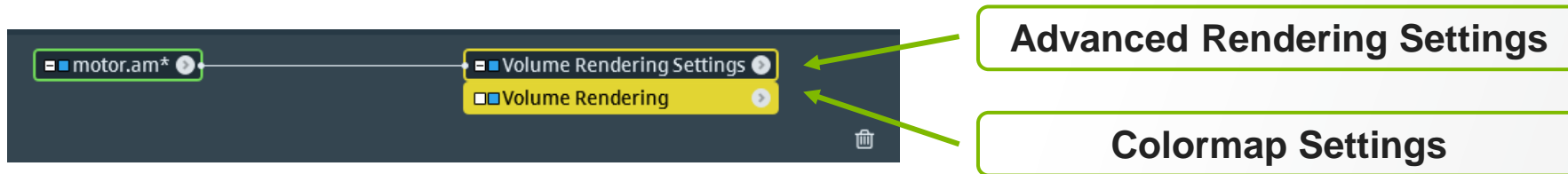
Setting a colormap: e.g. Ortho Slice

- A **colormap** is used to **map scalar values to intensity levels or colors**
- The **colormap range** can be modified manually in order to **adjust brightness, darkness or contrast**
- Predefined colormap settings are also proposed.

Some examples of grayscale colormap setting for Ortho Slice module (click on the **"Edit"** button of "Colormap" port):

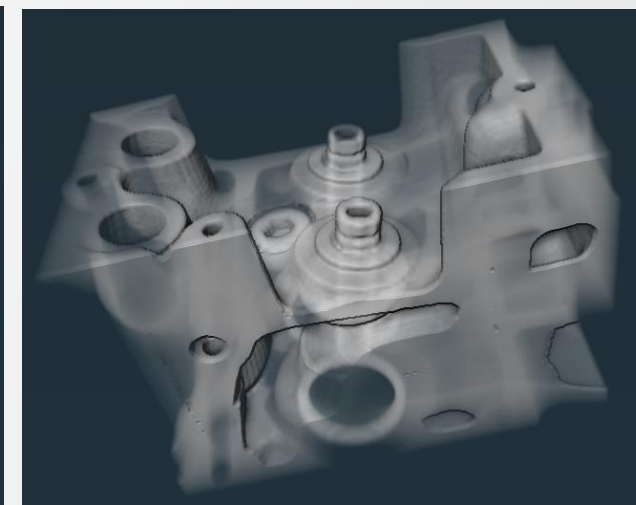
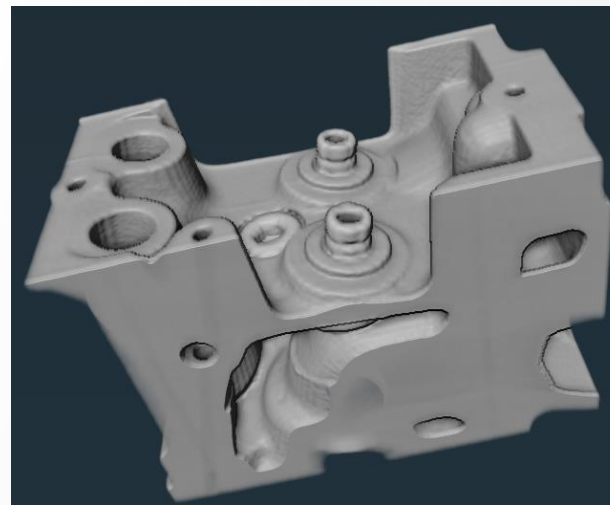
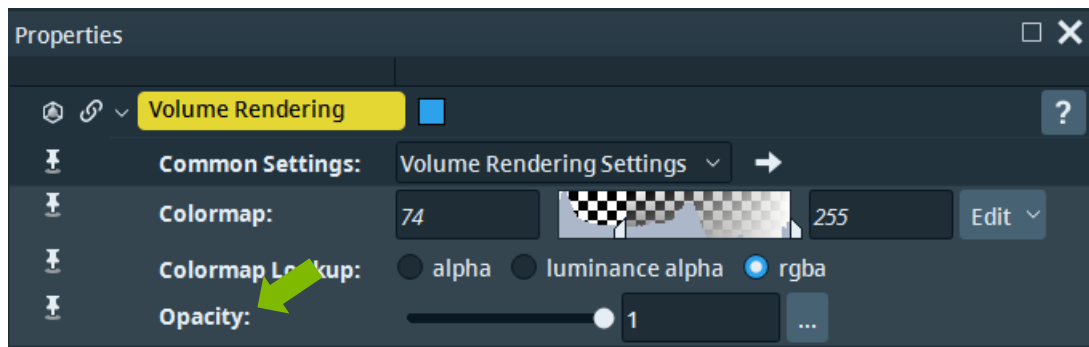


3D visualization with Volume Rendering



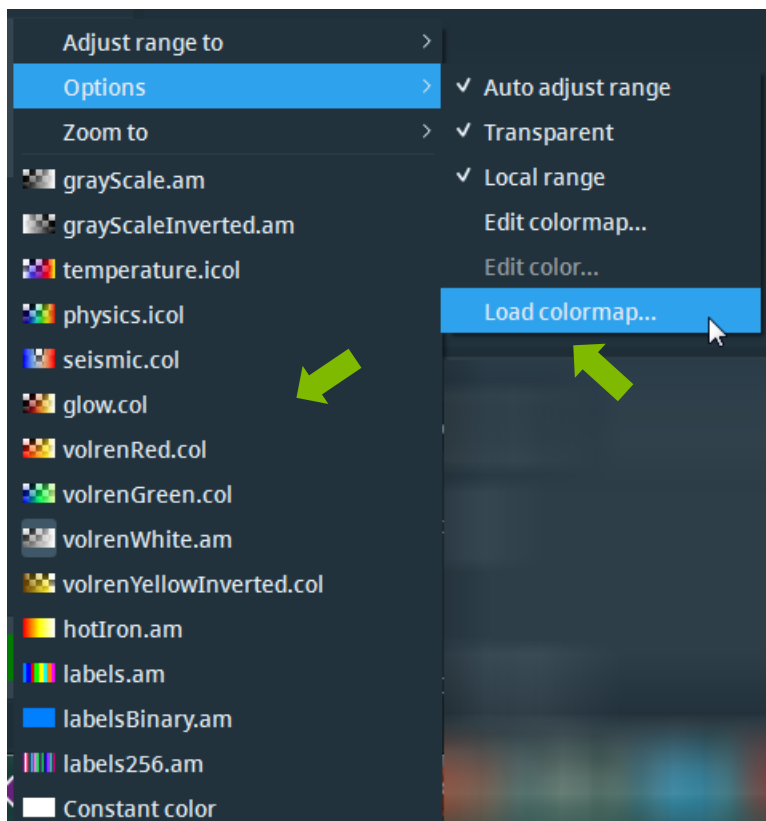
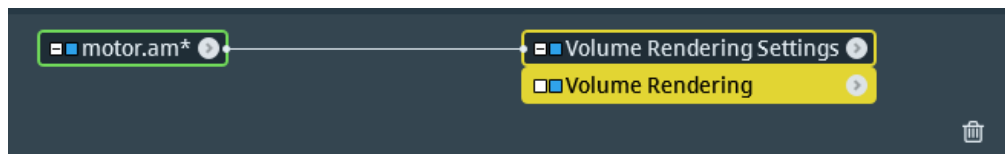
Volume rendering – colormap settings for assigning color and transparency to each voxel value

“Opacity” port – for tuning the transparency



3D visualization with Volume Rendering

Volume rendering: Colormap Settings



For changing the default colormap:

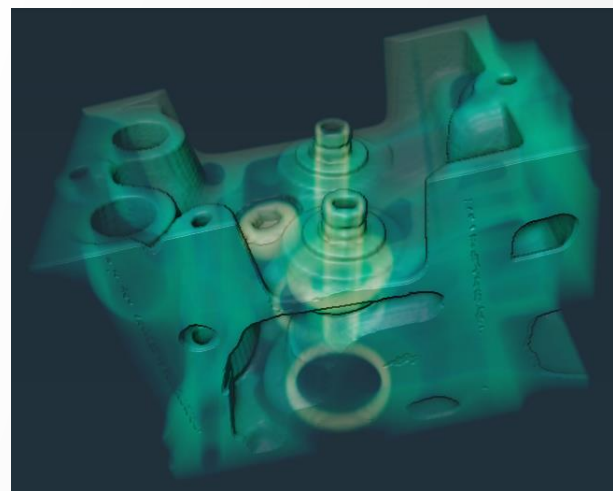
- Click on the “Edit” button of “Colormap” port
- Pick a colormap from the drop-down list

OR

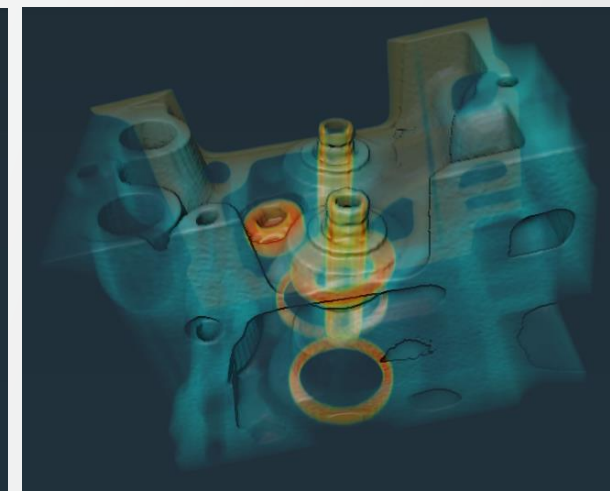
- Load a colormap from the disk

Once loaded, a colormap will be added to the drop-down list

volrenGreen
Colormap
(default)

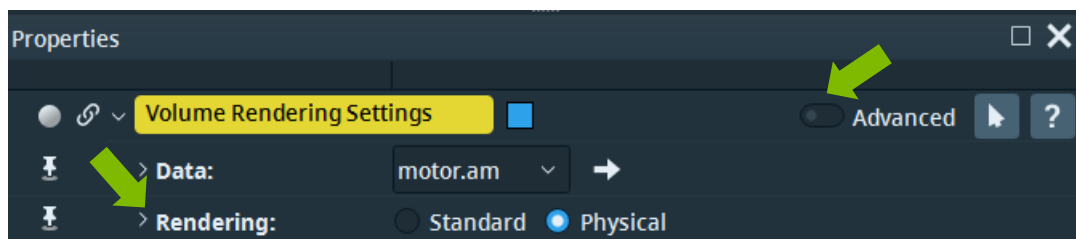


volrenPhysics
Colormap
(loaded from disk)



3D visualization with Volume Rendering

Volume rendering Settings

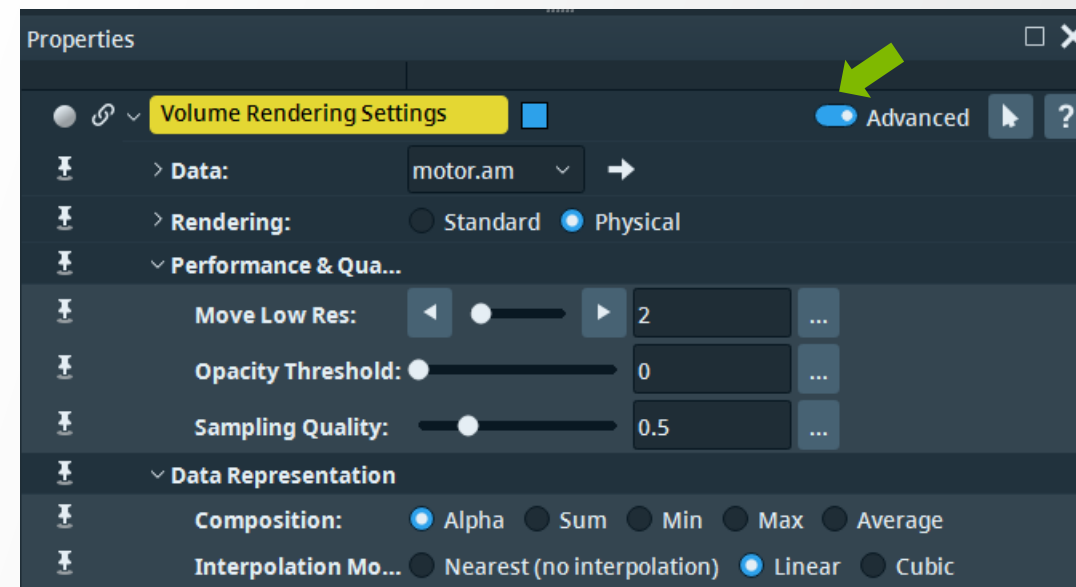


Rendering type:

- Standard
- Physical – mostly used

According to the selected rendering type, different rendering options are proposed.

Click on the arrow on the left of the “Rendering” port in order to show more settings.



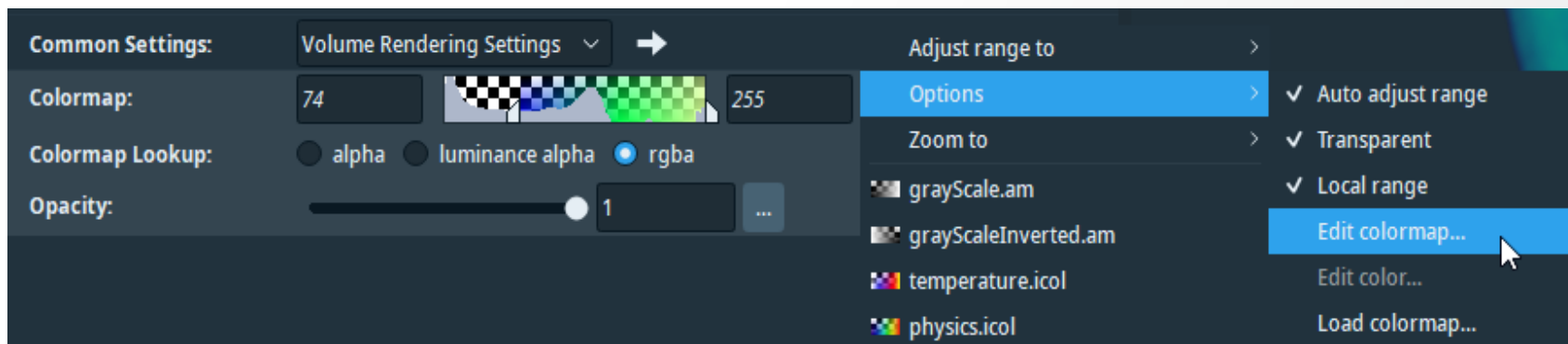
Switch on the “Advanced” ribbon for advanced Volume Rendering settings

- “Move Low Res”– low resolution mode when moving the camera, for real time rendering

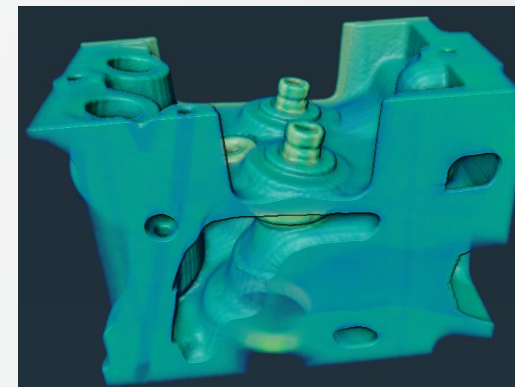
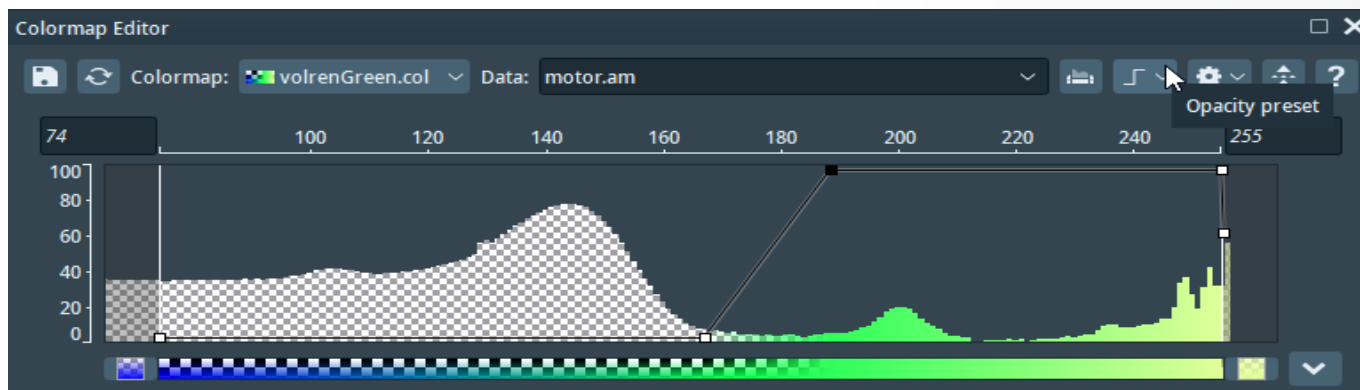
Setting a colormap: Colormap Editor

In addition to choosing a default colormap or loading one from the disk, one can also edit a colormap by means of **Colormap Editor**. To access Colormap Editor:

- Click the “**Edit**” button of the “Colormap” port of any visualization module and select **Options -> Edit Colormap**



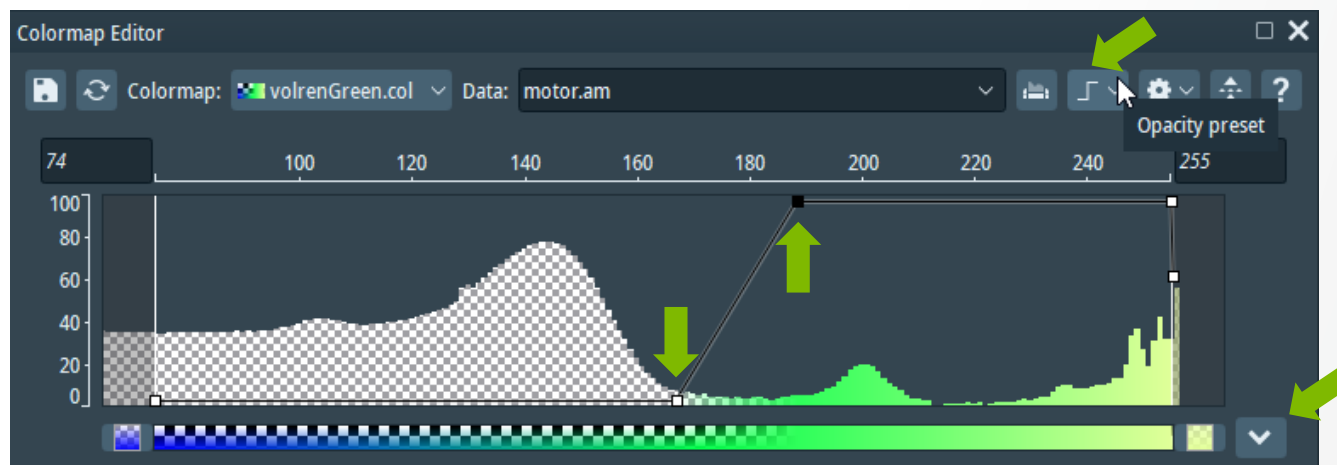
Colormap Editor window will be displayed on top of the Project View window:



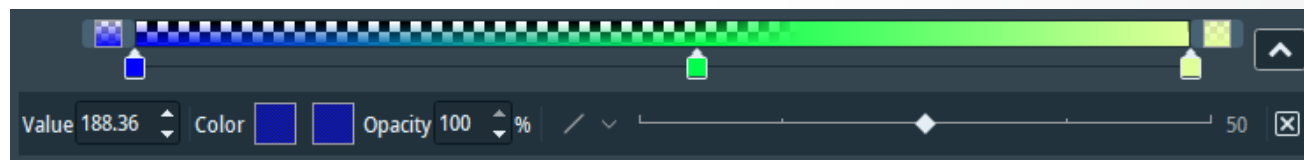
Setting a colormap: Colormap Editor

Opacity curve – allows controlling the transparency of the colormap:

- Pick a default preset from the “**Opacity preset**” menu
- Manually adjust the curve:
 - Left-click on the curve to add a point at the respective location
 - Click and hold on a point in order to move it
 - Right click on a point in order to remove it



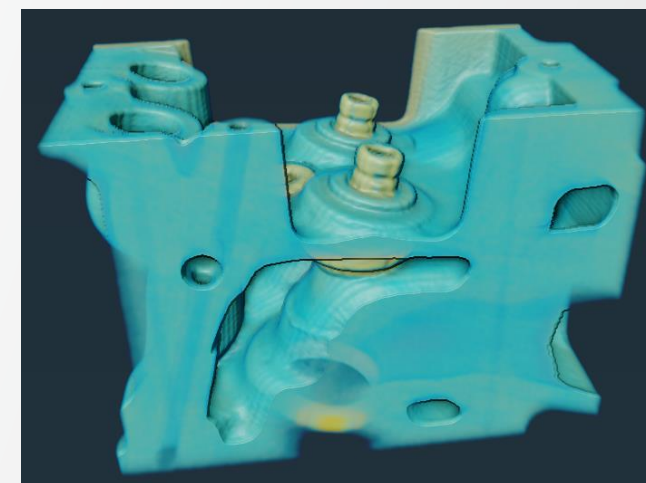
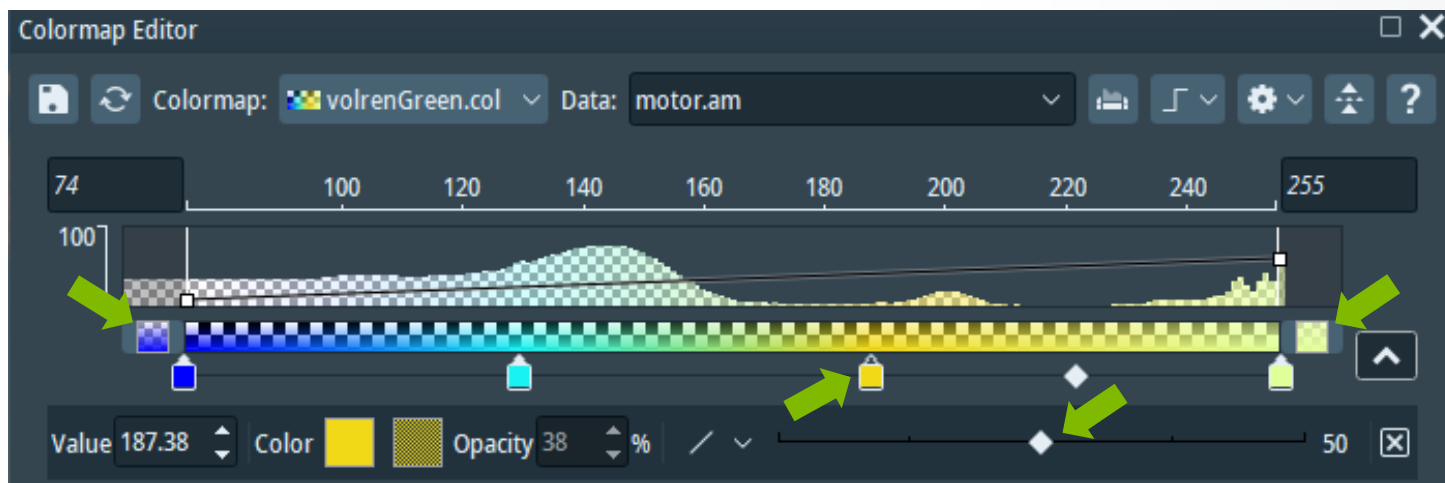
Click on the arrow on the Editor's bottom-right corner for opening the **Color Editor** (below the histogram):



Setting a colormap: Colormap Editor

Colormap gradient – allows modifying the colormap using color markers

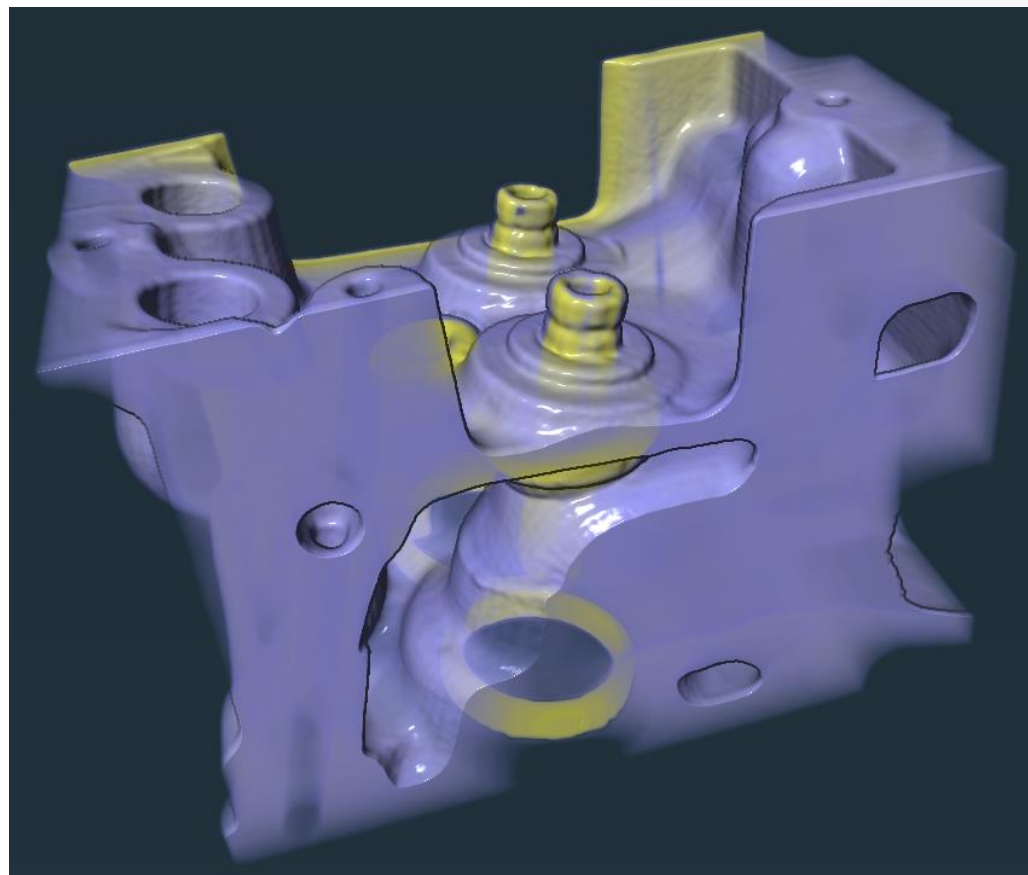
- To modify the color gradient:
 - Left-click on the markers line to **add a marker** at the respective location
 - Click and hold a marker in order to **move** it
 - Right click on a marker in order to **remove** it
 - Double click on a marker for **color settings**
 - Drag the **diamond shaped button** to adjust the location of the inflection point
- The data points outside the colormap range will be mapped to the color defines by the extreme left and right boxes.



Data visualization: exercise 3

Setting colormaps

Use the Volume Rendering module and tune the colormap to obtain a similar view:

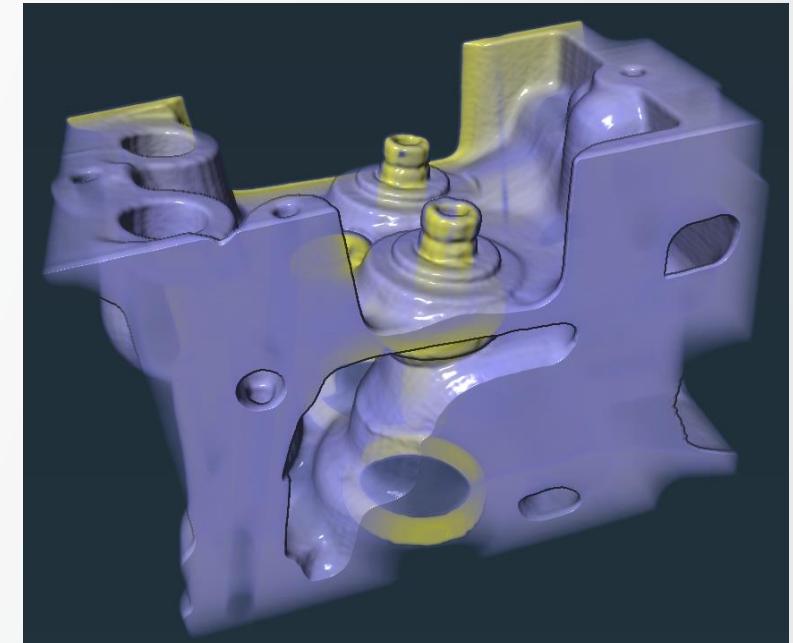


Data visualization: exercise 3

Solution

Colormap Editor Settings:

- Add and move points on the opacity curve for setting the transparency of the colormap
- Add and tune color markers for setting the color gradient of the colormap

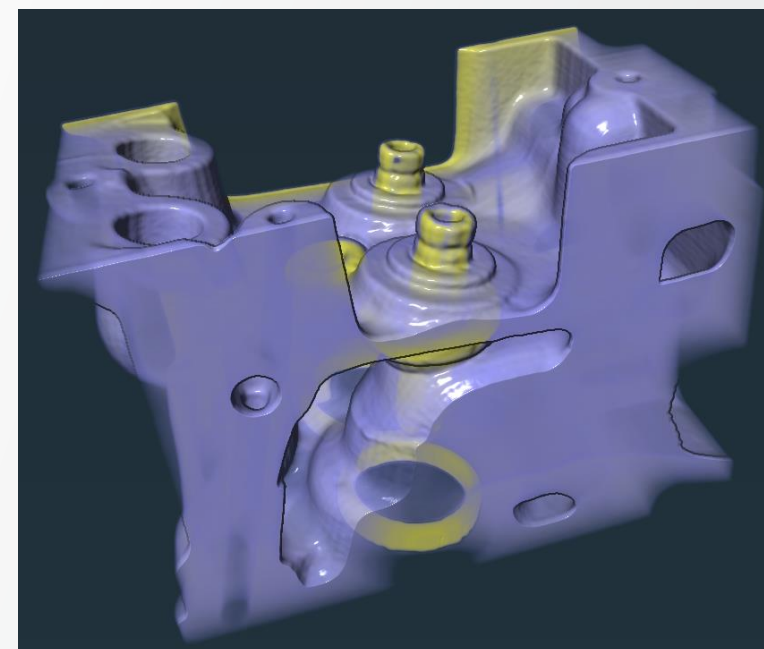
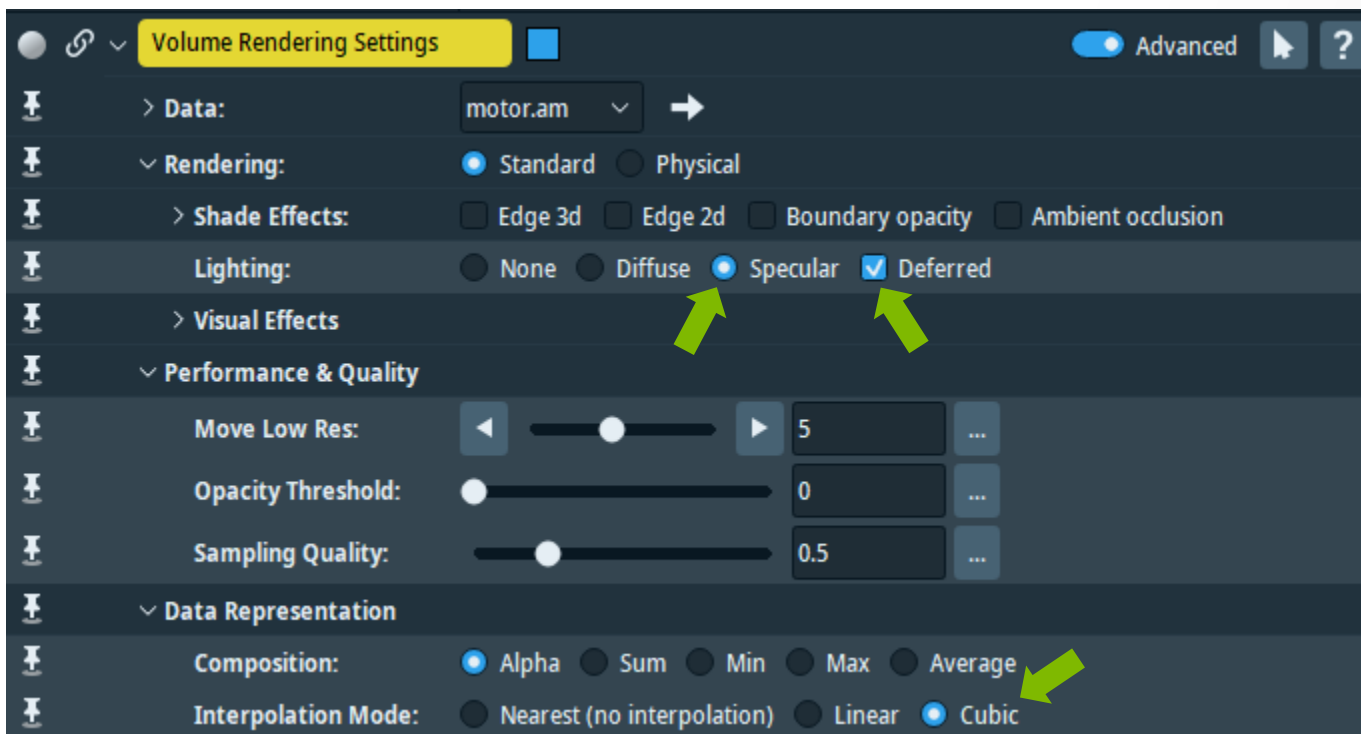


Data visualization: exercise 3

Solution

Volume Rendering Settings:

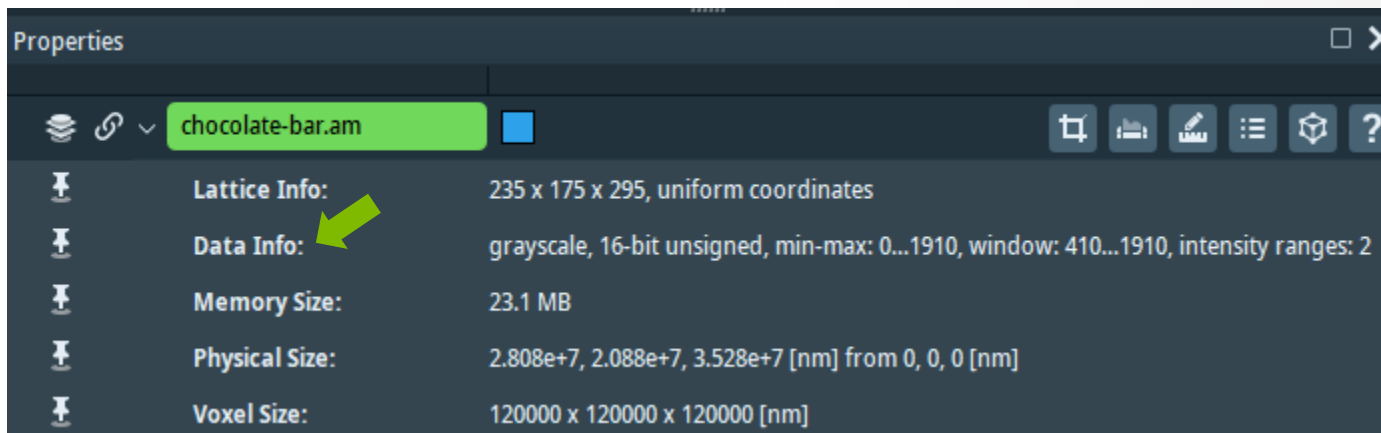
- Adjust the lighting effects: specular and deferred for highlighting reflections and shadows
- Choose interpolation mode: cubic for smoother result



Basic data manipulation

Data and voxel properties

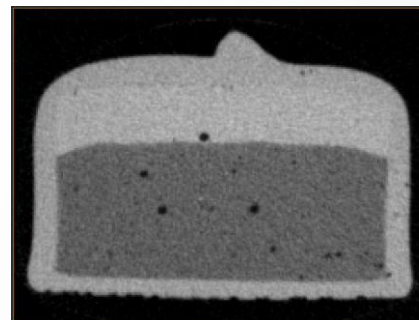
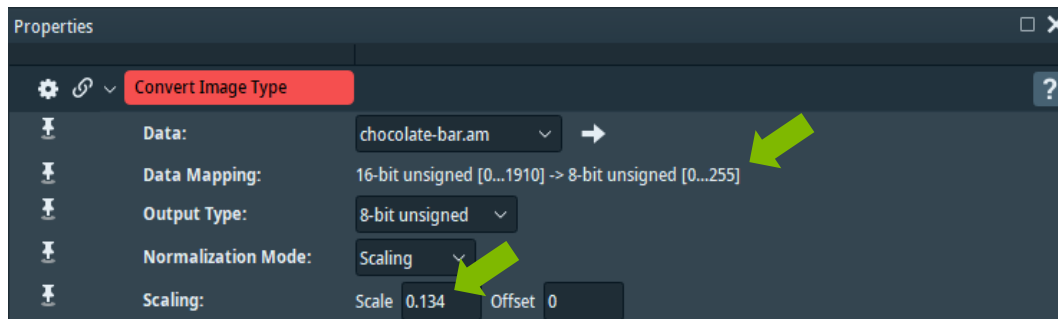
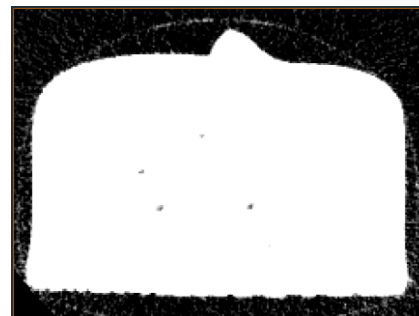
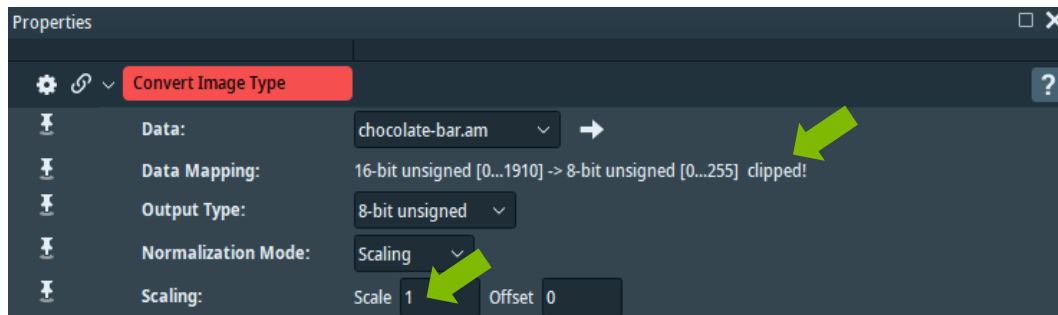
Click on a data in the pool in order to have **data and voxel properties** displayed in the properties window:
e.g. chocolate bar:



- **Type**: grayscale, label, RGBA, etc.
- **Precision**: number of bits used for coding the value stored by a voxel. E.g.:
 - 8-bits <-> values in [0-255]
 - 32-bits float <-> values in $\sim [-1e38, 1e38]$, finer precision but 4x more memory required
- **Minimum** and **Maximum voxel values** – give the intensity range (do not confuse with colormap range)
- **Window**: voxel values range outside the background

Converting types and re-mapping intensities

Changing type: Convert Image Type module

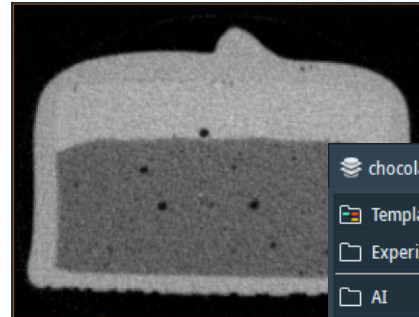
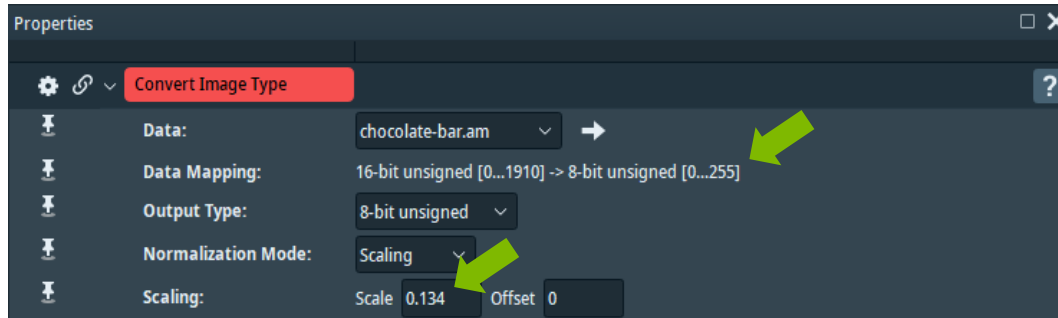
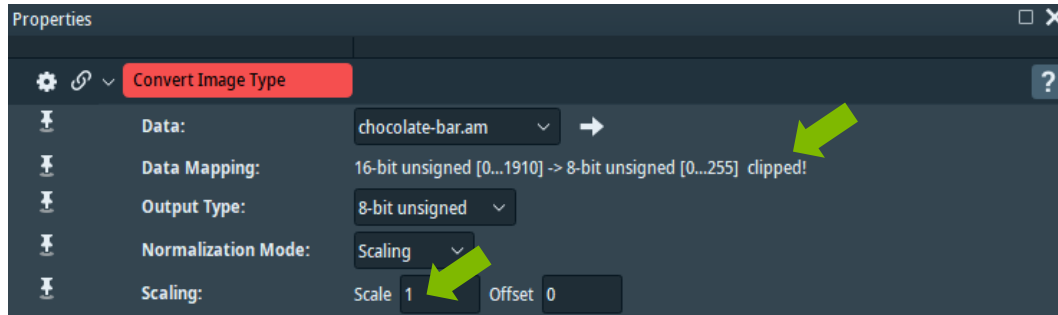


Scaling is necessary to avoid clipping. For scale tuning check:

- The intensity range of the input data
- The intensity range of the converted data

Converting types and re-mapping intensities

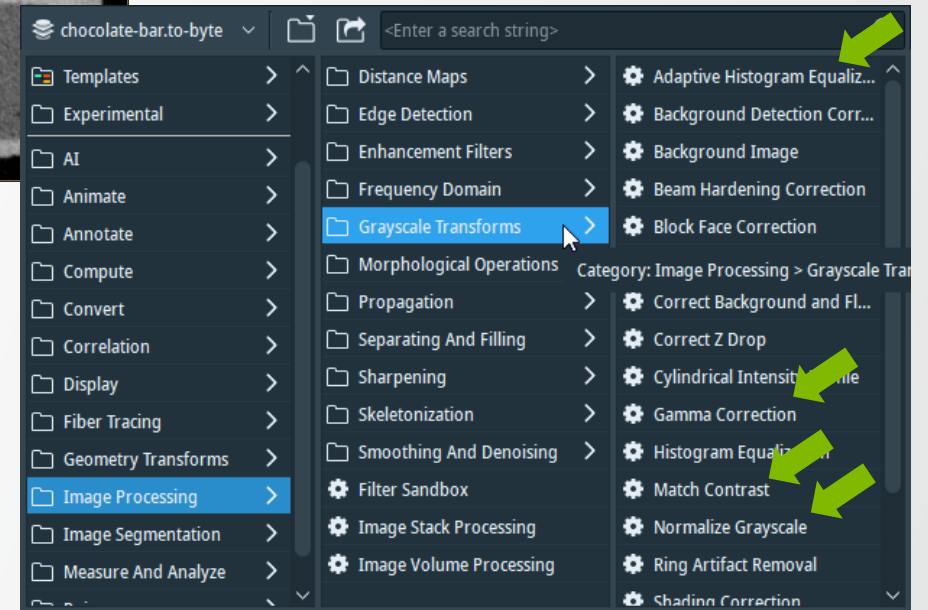
Changing type: Convert Image Type module



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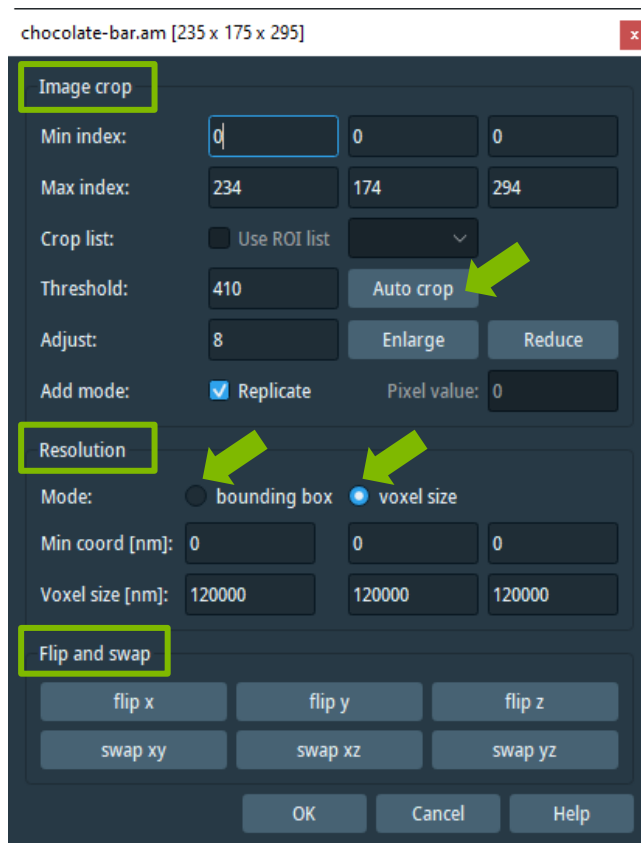
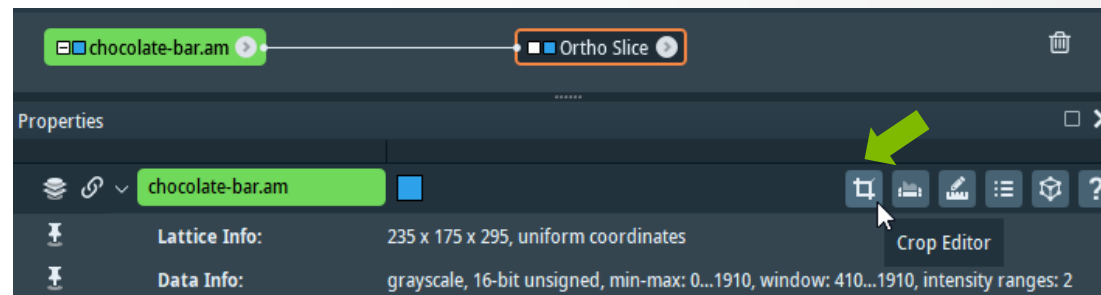
- The intensity range of the input data
- The intensity range of the converted data

Re-mapping intensities: Different modules are available in the category: Image Processing -> Grayscale Transform



Crop Editor: main functionalities

Access Crop Editor: select a dataset in the pool and click on the Crop Editor icon in the data properties window



Crop Editor – main functionalities:

- **Crop:** reduce/enlarge image frame
 - Manually
 - Automatically (by an automatically set gray-level threshold for separating the data into background and object)
- Change **resolution**
 - Change voxel size
 - Change bounding box size (the new voxel size is automatically computed)

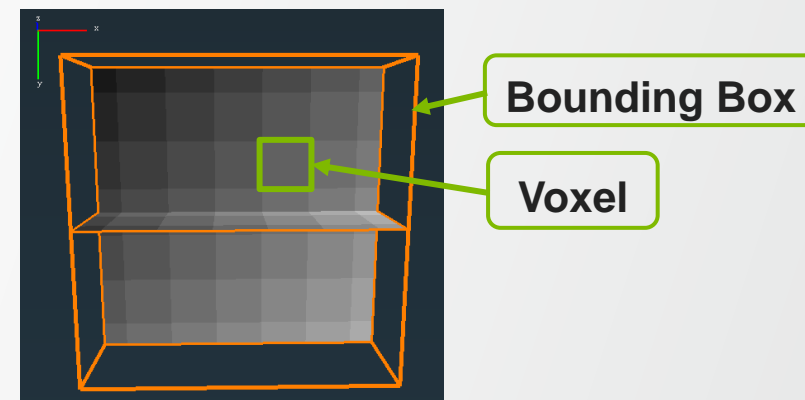
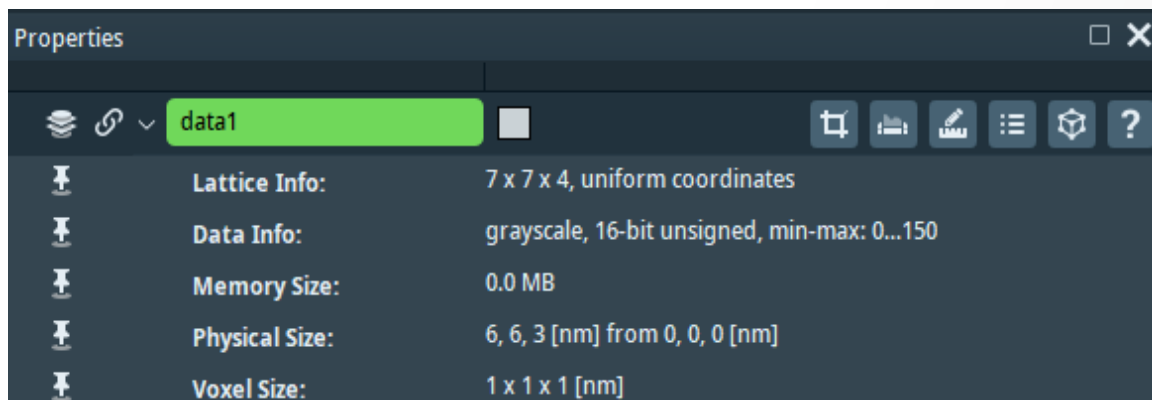
The number of voxels is preserved
- Modify **axes:**
 - Flip an axis' orientation – the slices along the respective orientation will have their order reversed
 - Swap – allows interchanging two axis

Crop Editor: good practices

Note: **Bounding Box** is defined from voxel centers, i.e. :

$\text{bbox_size} = \text{voxel_size} * (\#\text{voxels} - 1)$ for each dimension (x, y or z)

A slice is defined from voxels centers too.

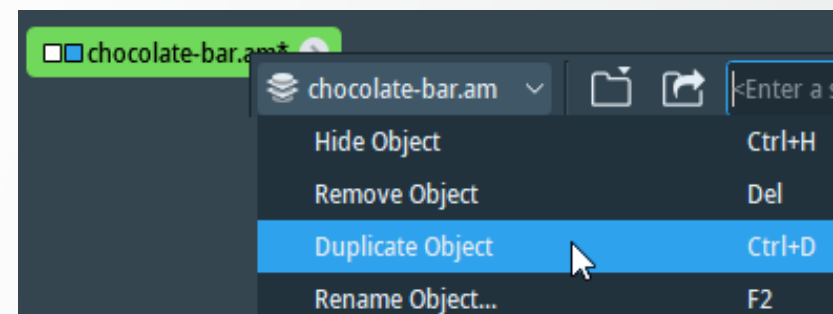


Warning: editors directly modify the data

no undo available (the only way to get the original data back is by reloading/re-generating it)

Good practice: duplicate data before editing:

- Keyboard shortcut: **[Ctrl] + [d]**
- Data object menu



Crop Editor: alternatives

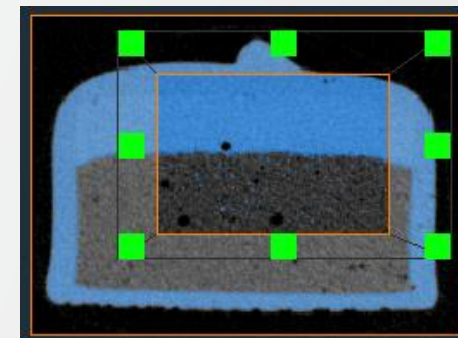
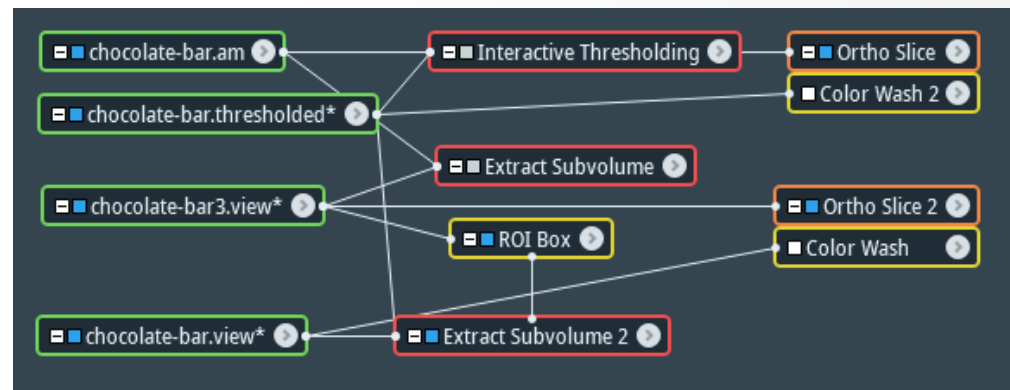
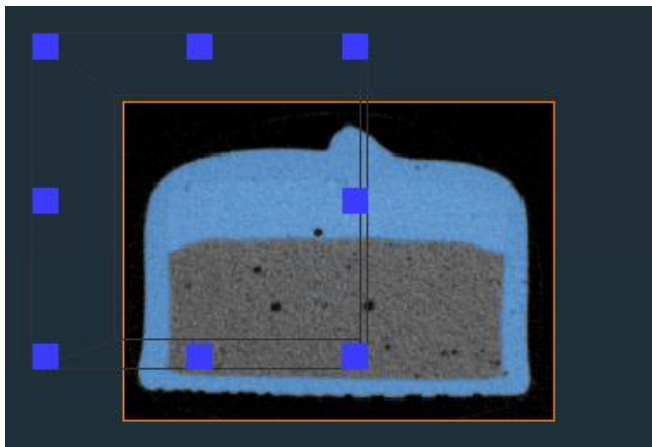
Extract Subvolume module can be used as an alternative to Crop Editor (for cropping only).

Extract Subvolume + ROI Box – allow cropping multiple datasets the same way:

e.g. input dataset and its segmentation result

- Extract the desired sub-volume of the input dataset (by means of Extract Subvolume)
- Connect a ROI Box to the extracted sub-volume
- Connect an Extract Subvolume module to the second dataset. Connect the ROI input of the Extract Subvolume module to the ROI Box module and then press Apply

=> The second dataset will be cropped as the first one.



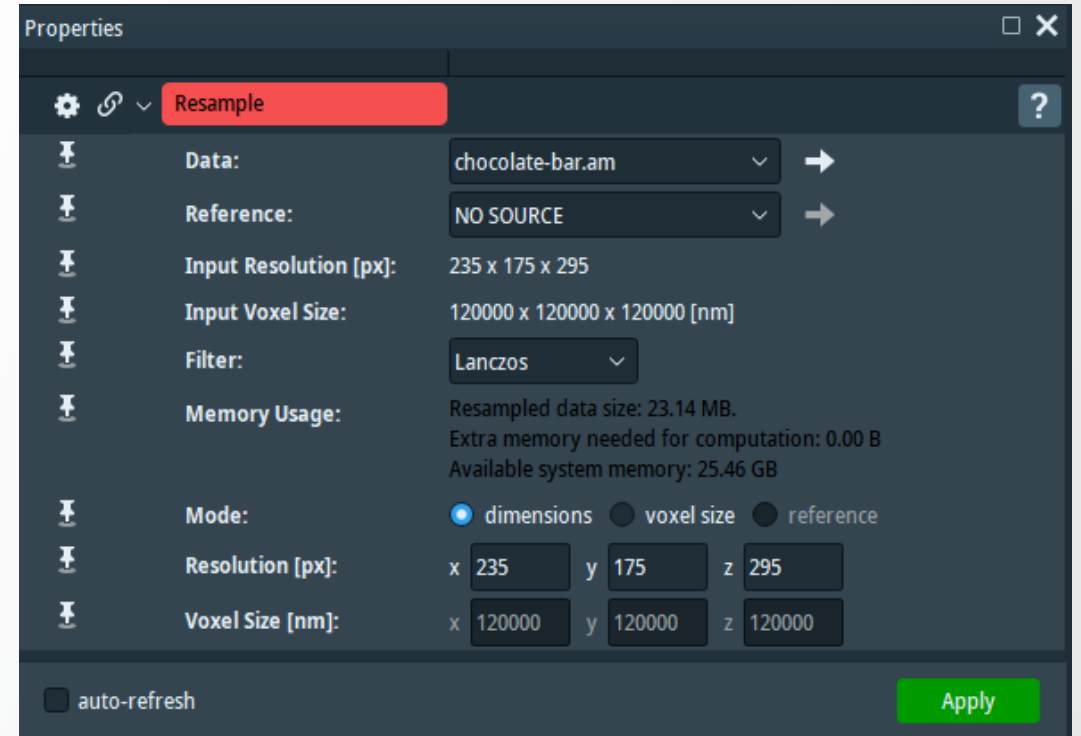
Data resampling

Resampling

Allows enlarging/shrinking the regular grid on which an image is defined (interpolation is necessary):

- Change the number of voxels
e.g. reduce => reduced data size but lowered quality
- Change voxel size
e.g. adjust size in order to make the voxels isotropic

This can be done in Avizo via the Resample module.



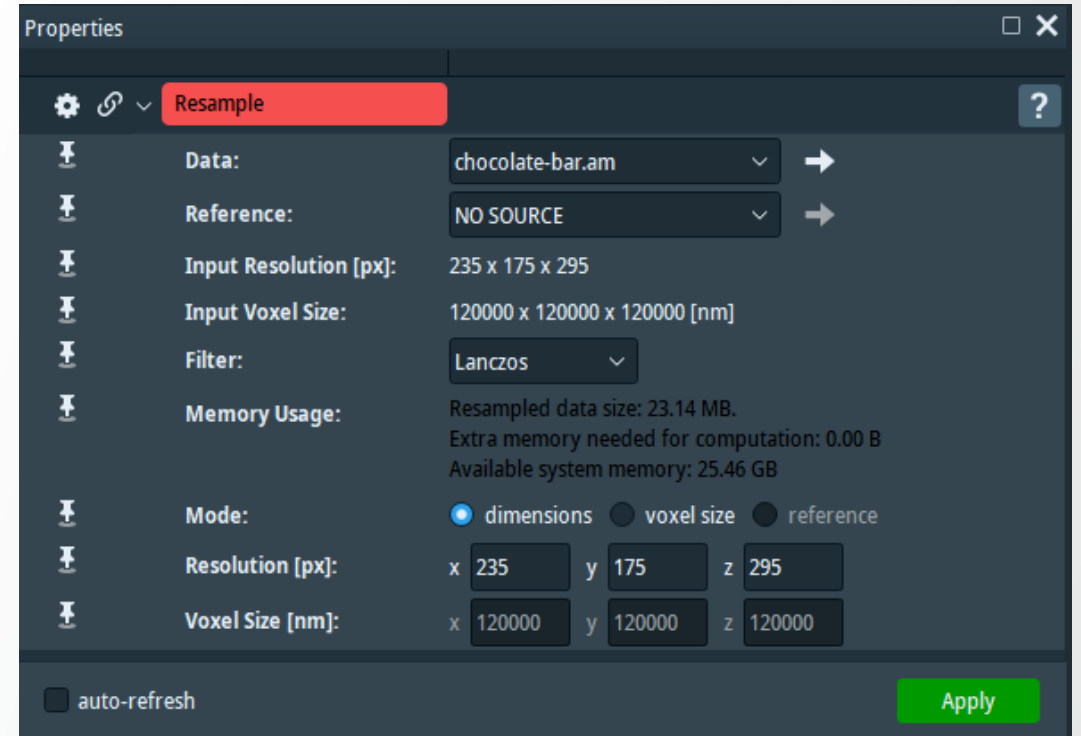
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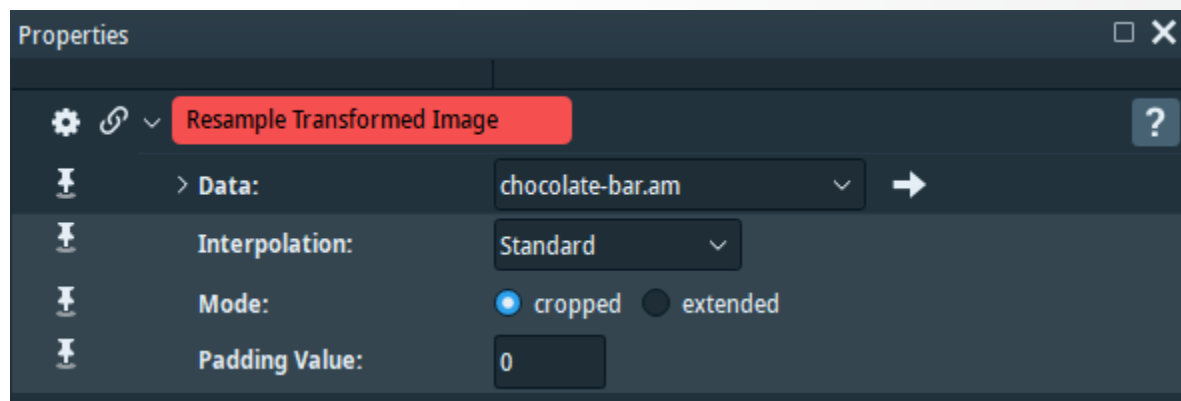
Data resampling – apply transformation

Resample Transformed Image module

Oftentimes, when a data is transformed in Avizo, only the visualization of the data is changed and not its representation in memory. Apply this module to implement the transformation carried by a dataset and to change the dataset representation in memory.

Use cases examples:

- Generate the data resulted after applying a rotation, scaling or other transformation
- Generate the resampled image after registration with a reference
- Apply the rotation necessary to a dataset after aligning the data bounding box with the object's axes.



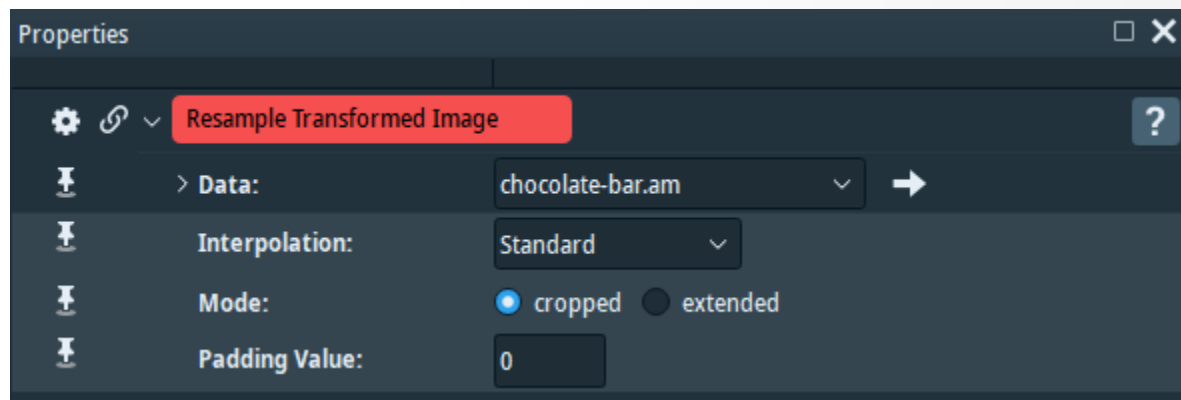
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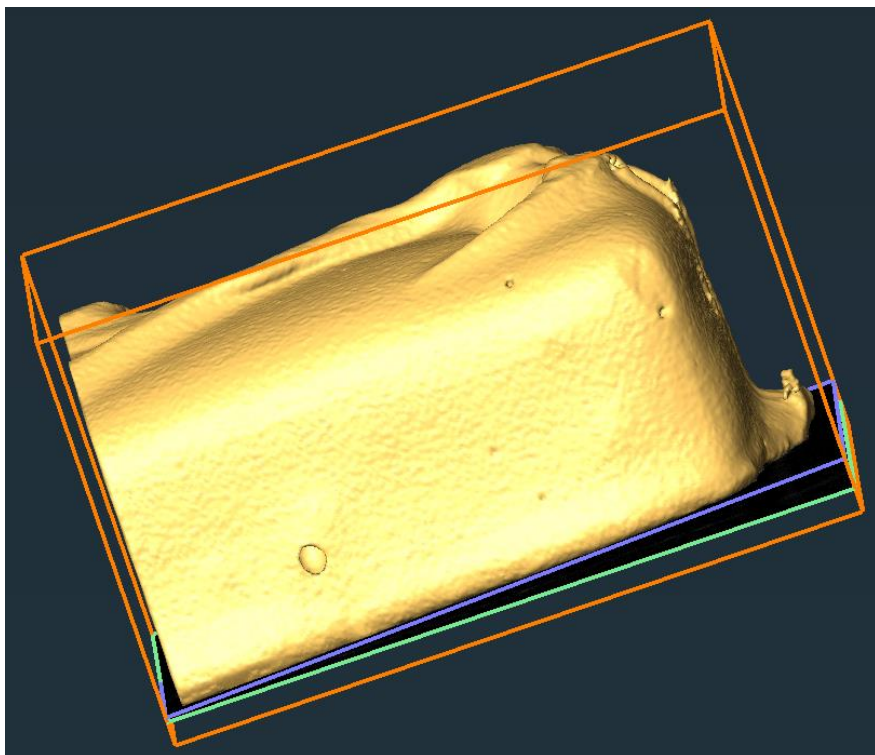
Data resampling example

Resampling to an oblique plane

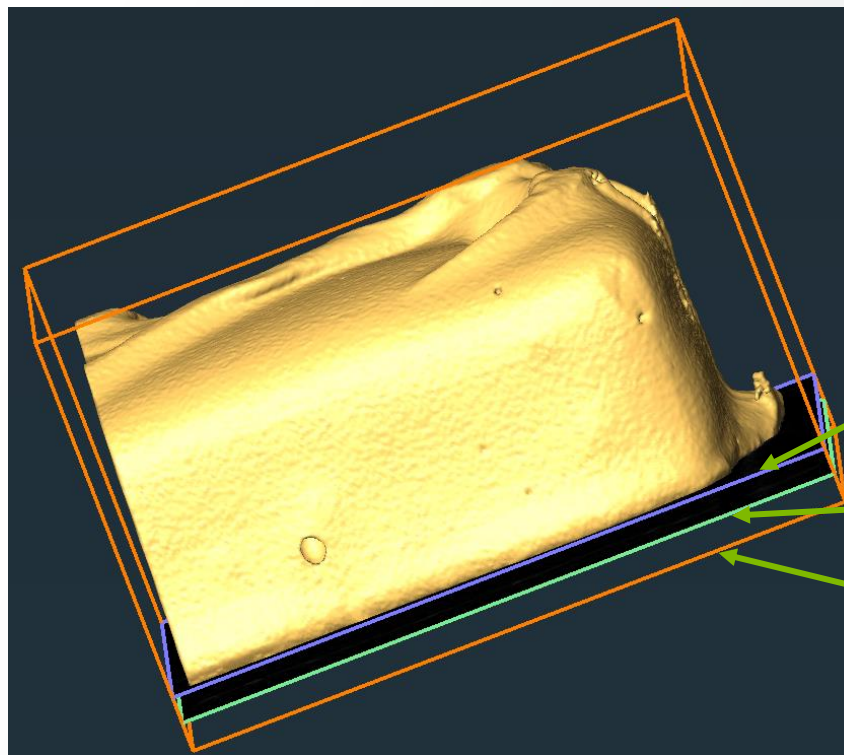
Issue: the object's axes and the bounding box's axes are not aligned

Goal: align the bounding box's axes to the object's axes

Before alignment



After alignment



Slice (aligned to the object's bottom plane)

Ortho Slice

Bounding Box

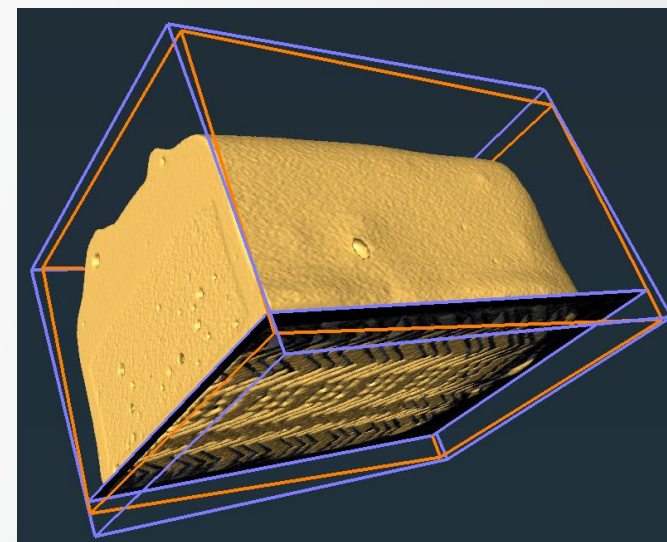
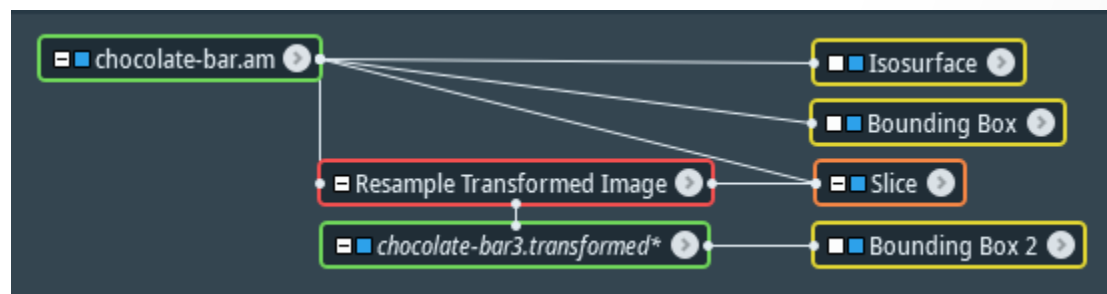
Data resampling example

Resampling to an oblique plane

Solution:

- Use “fit to points” option of **Slice** on an Isosurface or Volume Rendering and fit the Slice to the object’s xz plane (the bottom of the chocolate bar).
- Apply a **Resample Transformed Image** module and connect:
 - “Data” input to the data object
 - “Reference” input to the SliceSelect “extended” option and press Apply

A new data is generated with the bounding box’s axes aligned to the object’s axes.

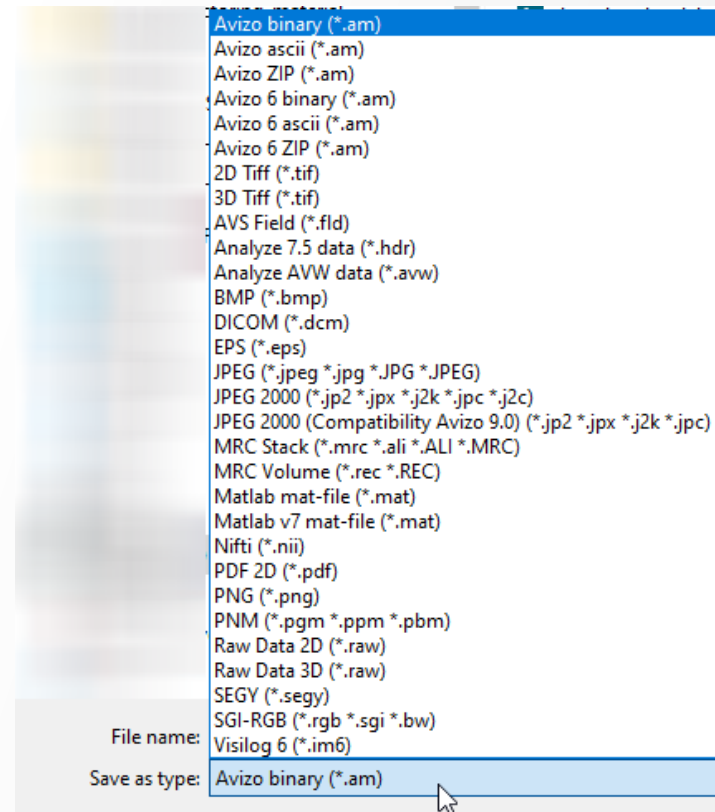
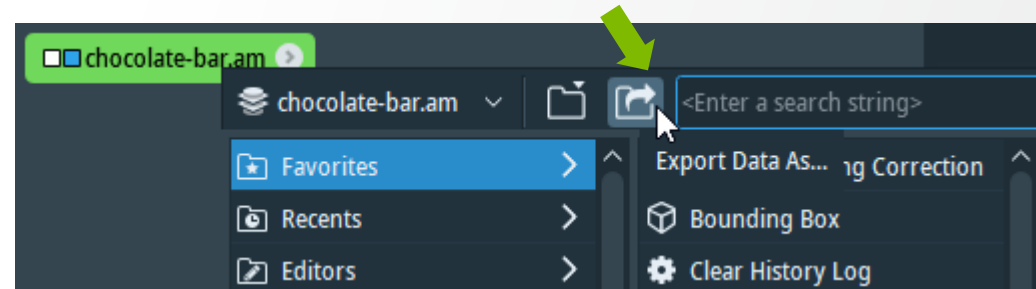


Export data

The results of the different processing modules can be exported from the Avizo pool.

Exporting data on the disk:

- Right-click on the dataset you want to save
- Click on the “Export data as” icon
- Select the relevant format



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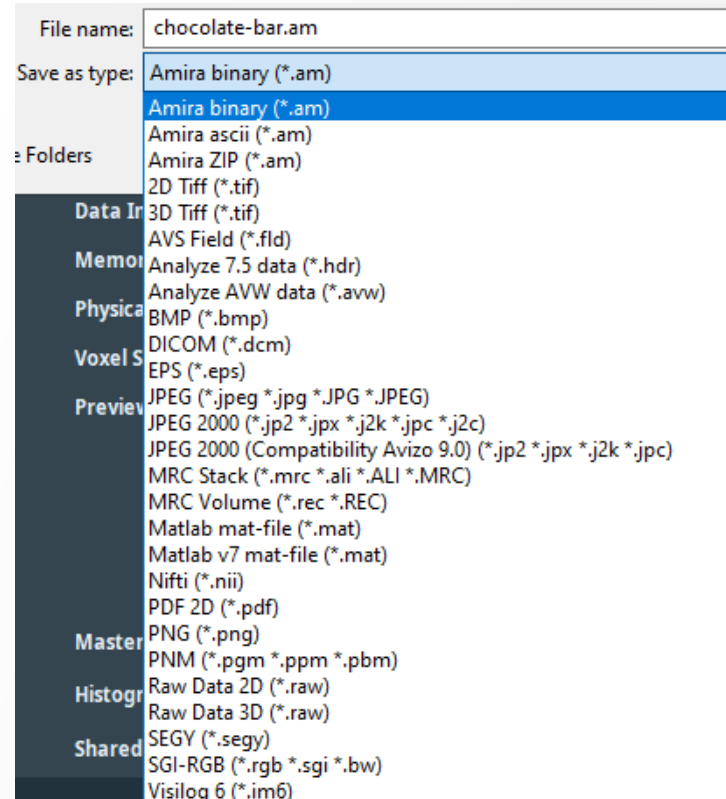
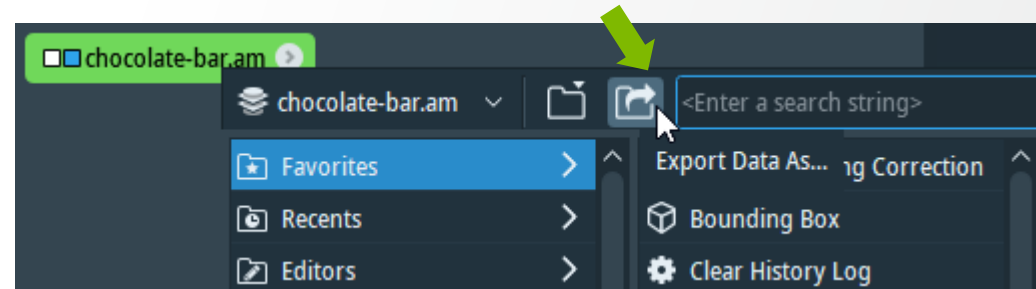


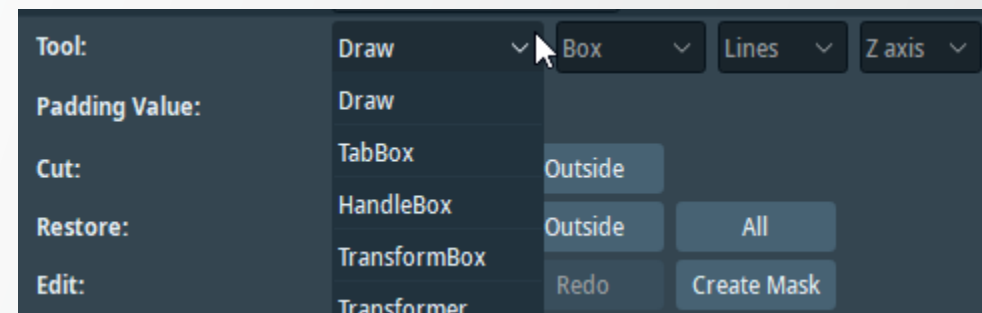
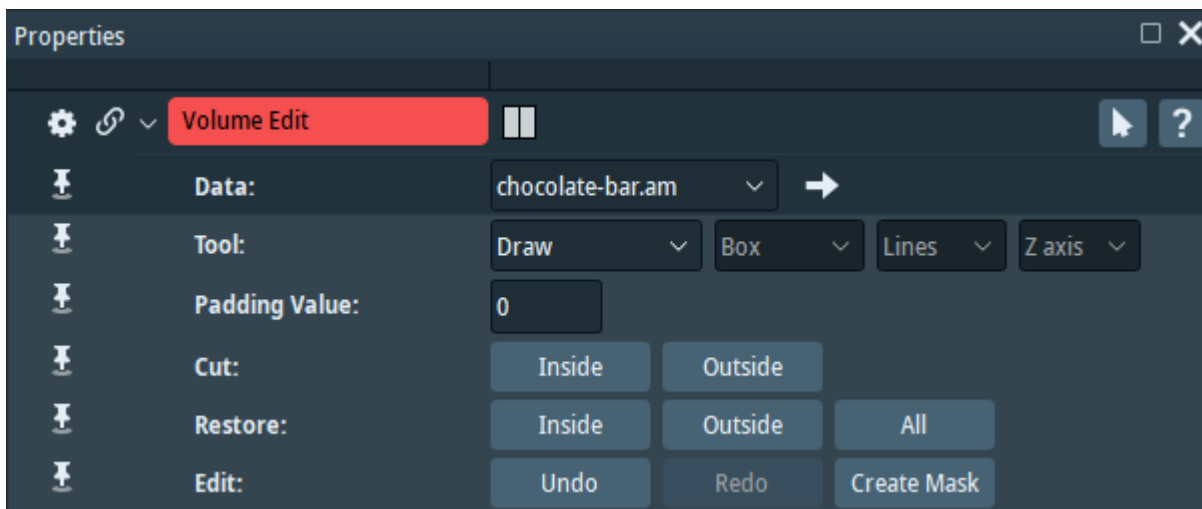
Image pre-processing: adjustments

Basic image data editing – Volume Edit

Volume Edit: interactive editing with various tools

Two types of tools are available:

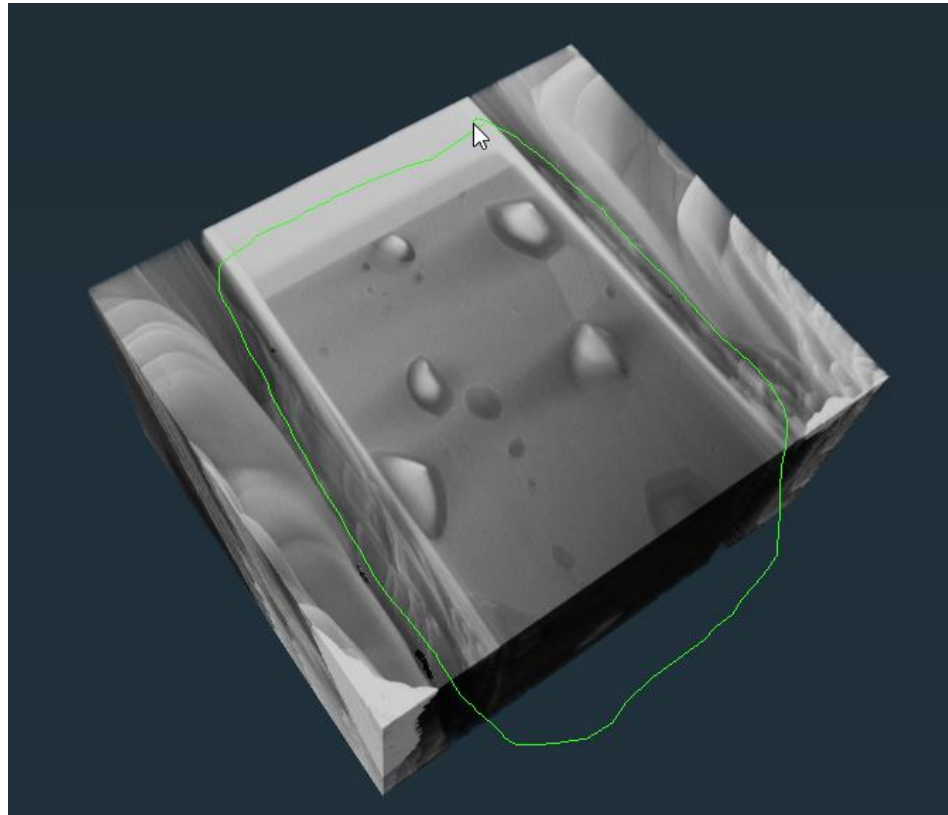
- A **draw tool:**
allows selecting the 3D projection behind a contour drawn in the viewer
- **Dragger tools:**
allow selecting a region by dragging, rotating, resizing a 3D shape (box, ellipsoid, cone, etc.).



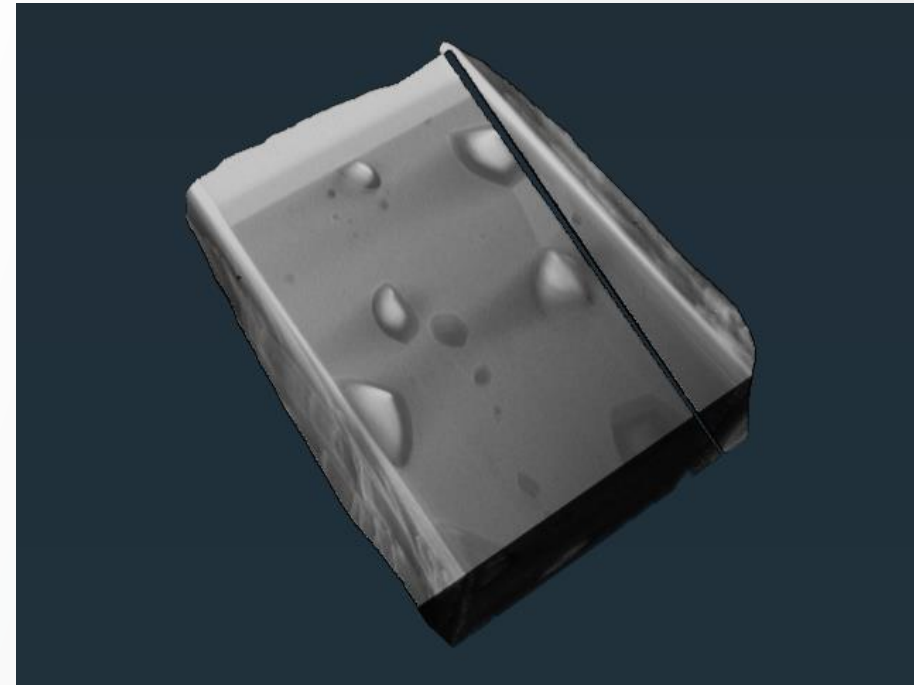
Basic image data editing – Volume Edit

Volume Edit – example of creating a sub-volume with the draw tool:

Draw tool selection



“Cut outside” result

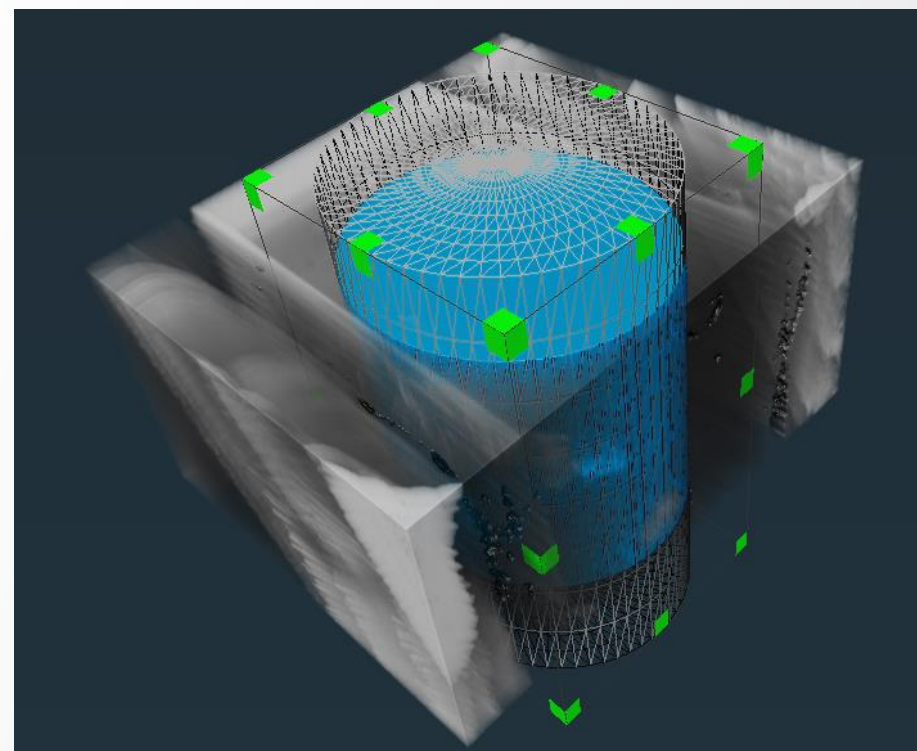
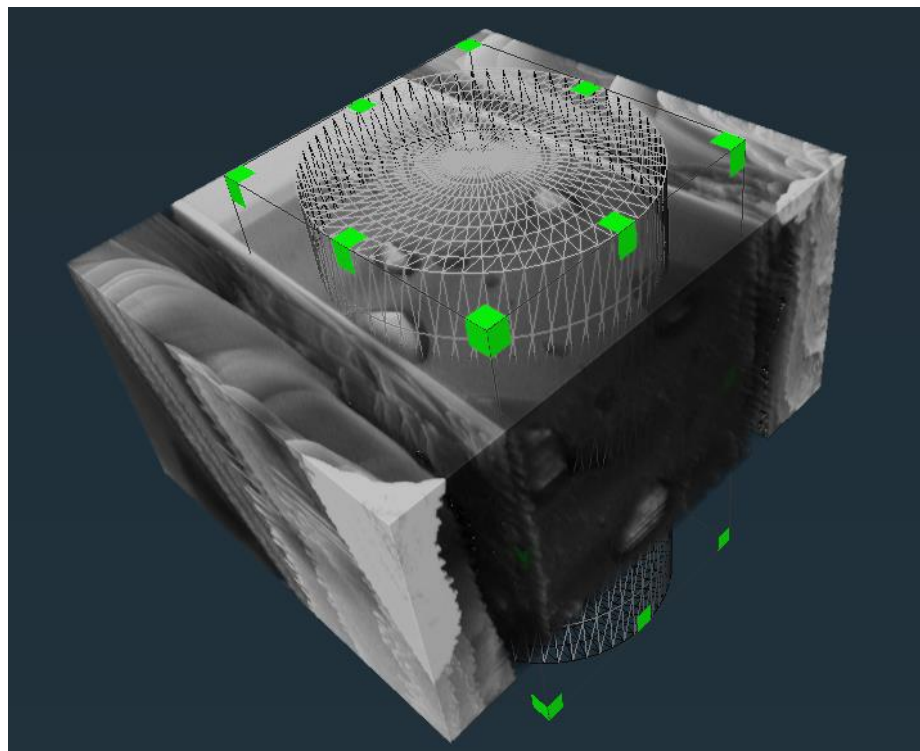


Data: MoSi2-shear-corrected.am

Basic image data editing – Volume Edit

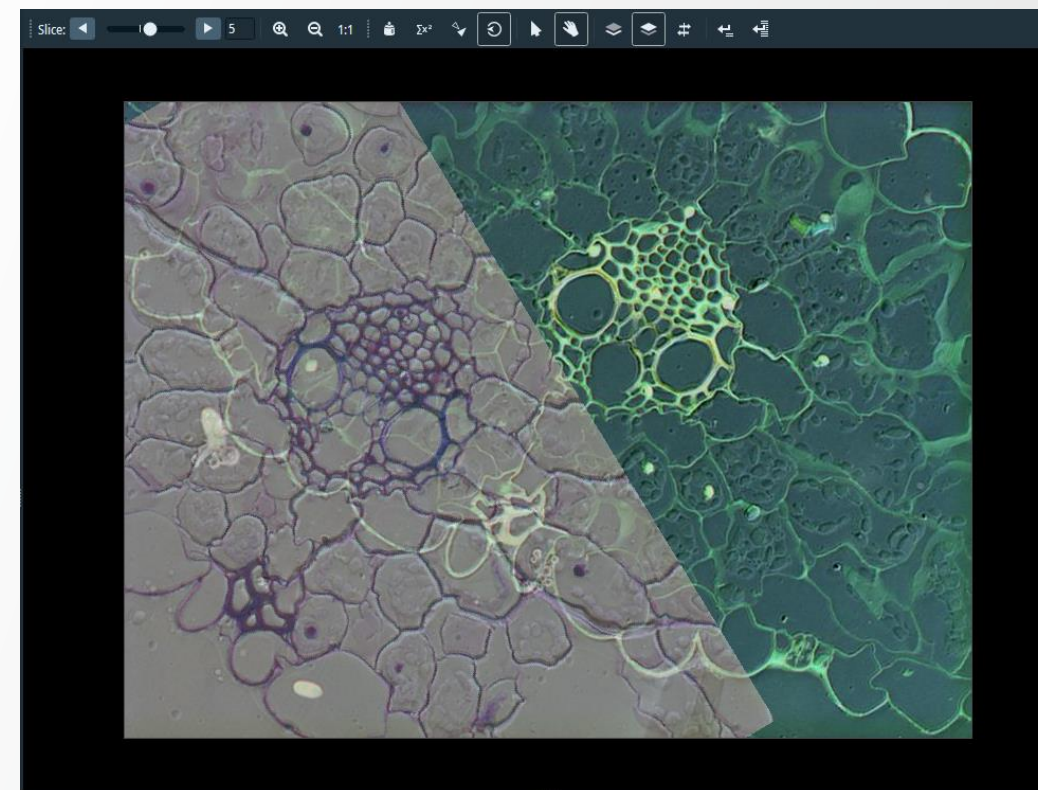
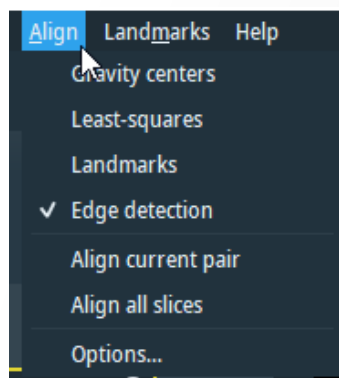
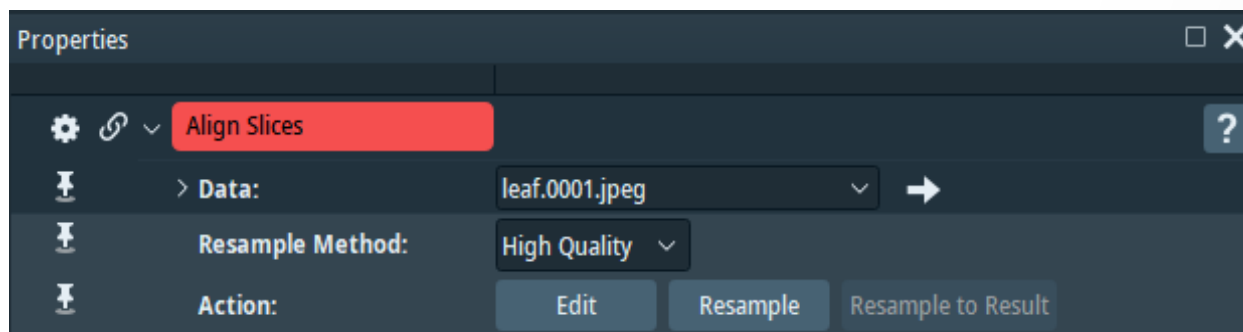
Volume Edit - example of creating a **Cylindrical Mask**:

- **Tool port** settings: TabBox, Cylinder, Z Axis
- Adjust cylinder using Orthographic Camera mode
- Set **Padding** value to the value of the voxels of the “exterior” (e.g. 0)
- Push buttons: **Cut – Outside** and **Edit – Create Mask**



Align Slices

- For serial sections (e.g. **Light Microscopy**)
- Pushing the **Edit** button activates the **Alignment viewer** and **tools** and the Align and Landmarks menus
- Visualization of two consecutive slices in overlay

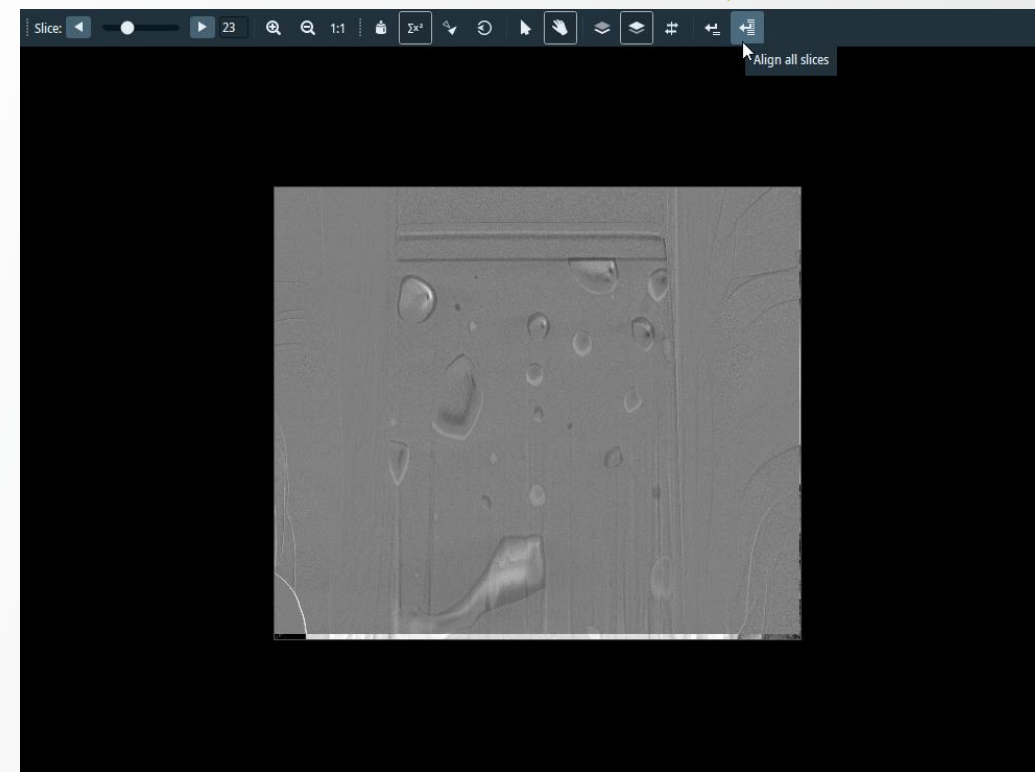


Data: leaf image stack

Align Slices

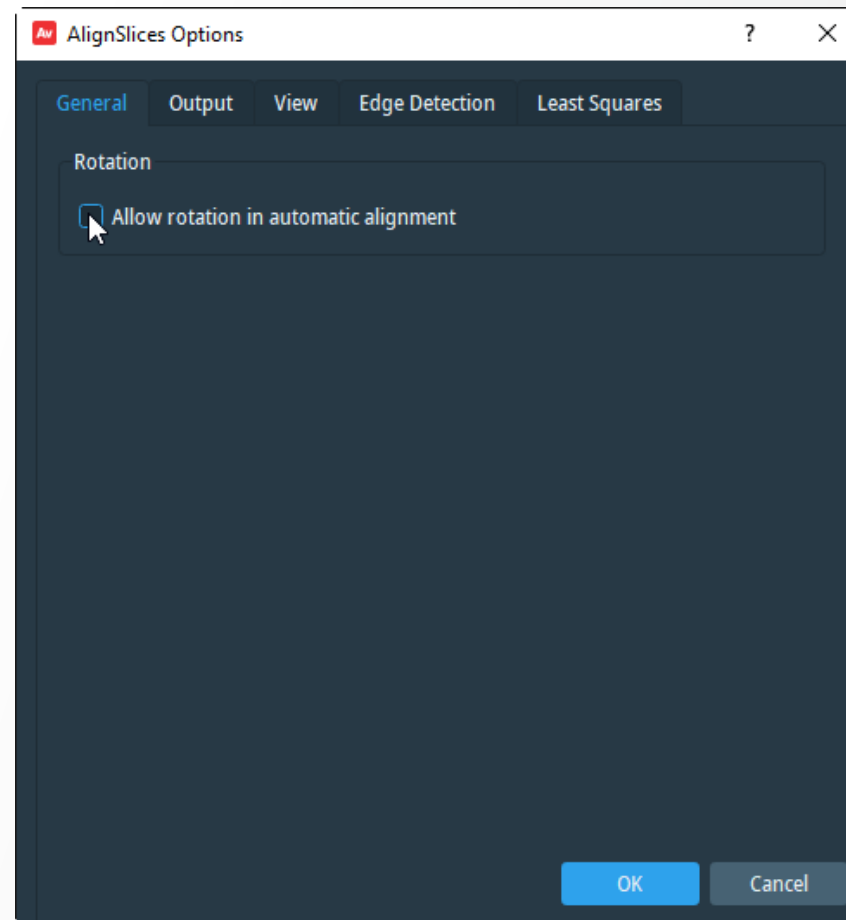
- Available operations:
 - Translate
 - Rotate
 - Mirroreach slice with respect to the next one.
- Modes and options (some examples):
 - Manual
 - Land-Mark
 - Intensity-based
- Possibility to use a mask
- **Resample** aligned stack (by pressing the Resample button of the module).

Automatic alignment modes



Align Slices

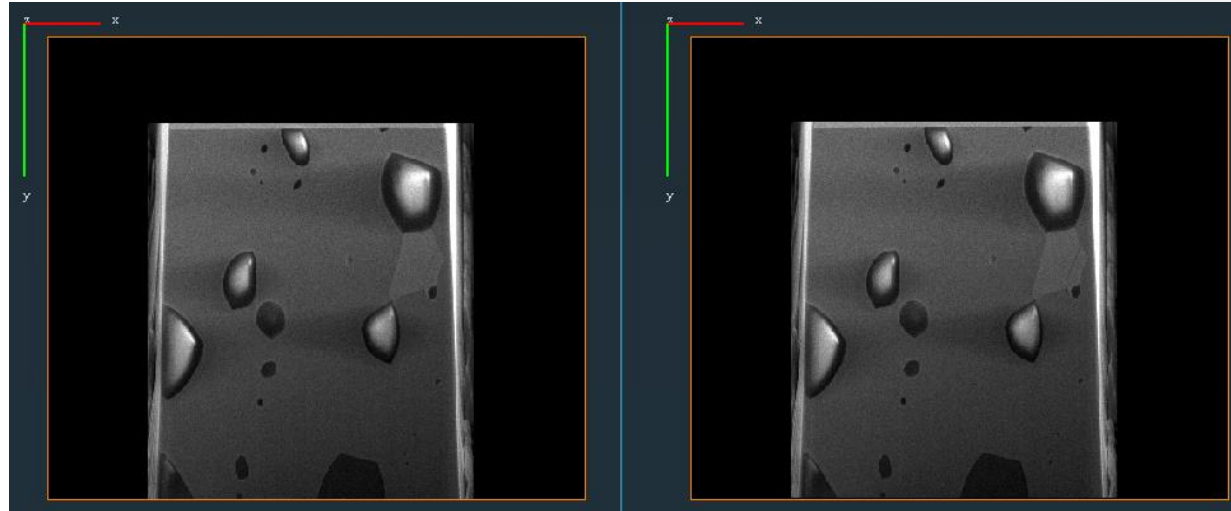
- Rotation alignment should be disabled for FIB-SEM (Align / Options)
- No rotation while FIB-SEM data collection!
- For disabling rotation go to Align menu – Options in order to access the **AlignSlices Options** pop-up.



Align Slices

Alignment example – comparison of raw data set (left-side) with aligned data set (right-side)

First xy slices of the volume



Last xy slices of the volume

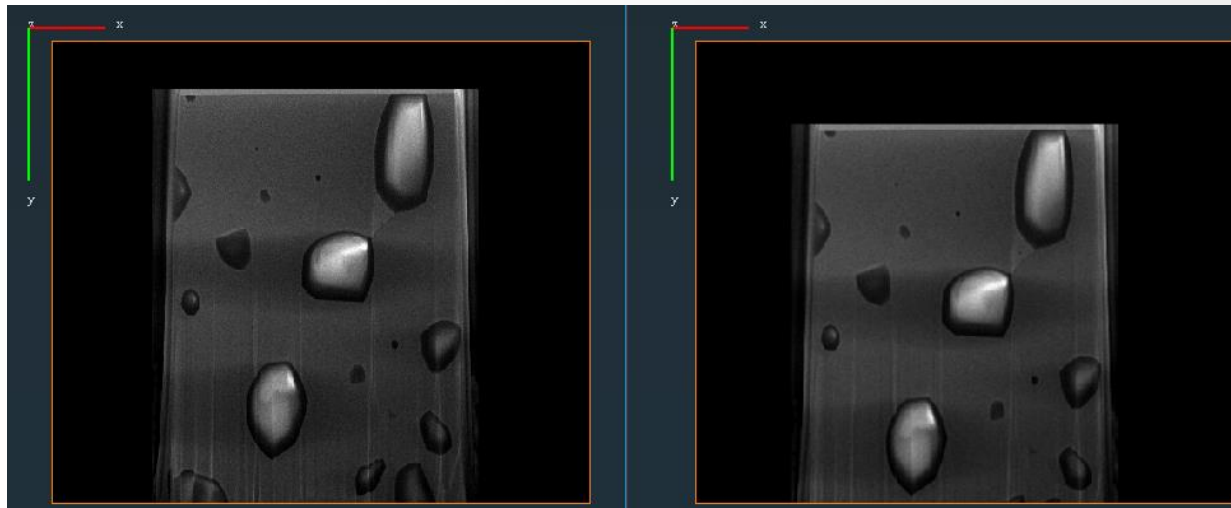


Image pre-processing: filtering

Introduction to spatial domain filtering

Filtering – enhance the data quality

Most filters operate in the **spatial domain** – each pixel/voxel is evaluated and its filtered value is given by applying a formula to the values of its neighbors in the input data:

- The **neighborhood** type needs to be defined
- The **formula** is filter specific.

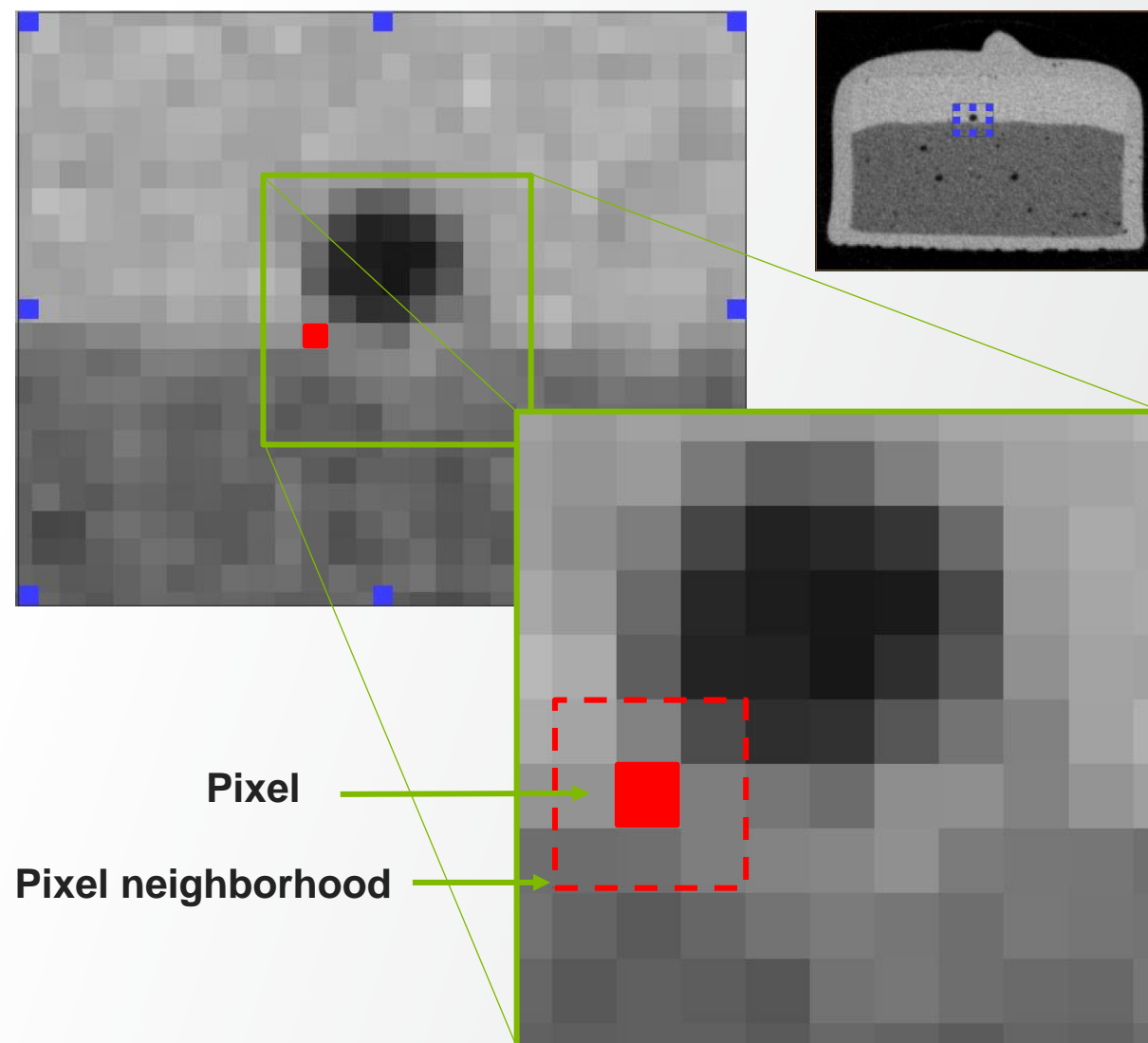


Image filtering: how to apply a filter in Avizo

Various **filtering modules** are available in Avizo.

They are mainly grouped according to their types into different sub-categories of the **Image Processing** category :

- Edge Detection
- Enhancement Filters
- Sharpening
- Smoothing and Denoising
- ...

Right click on the data set in order to
Access the module category menu.

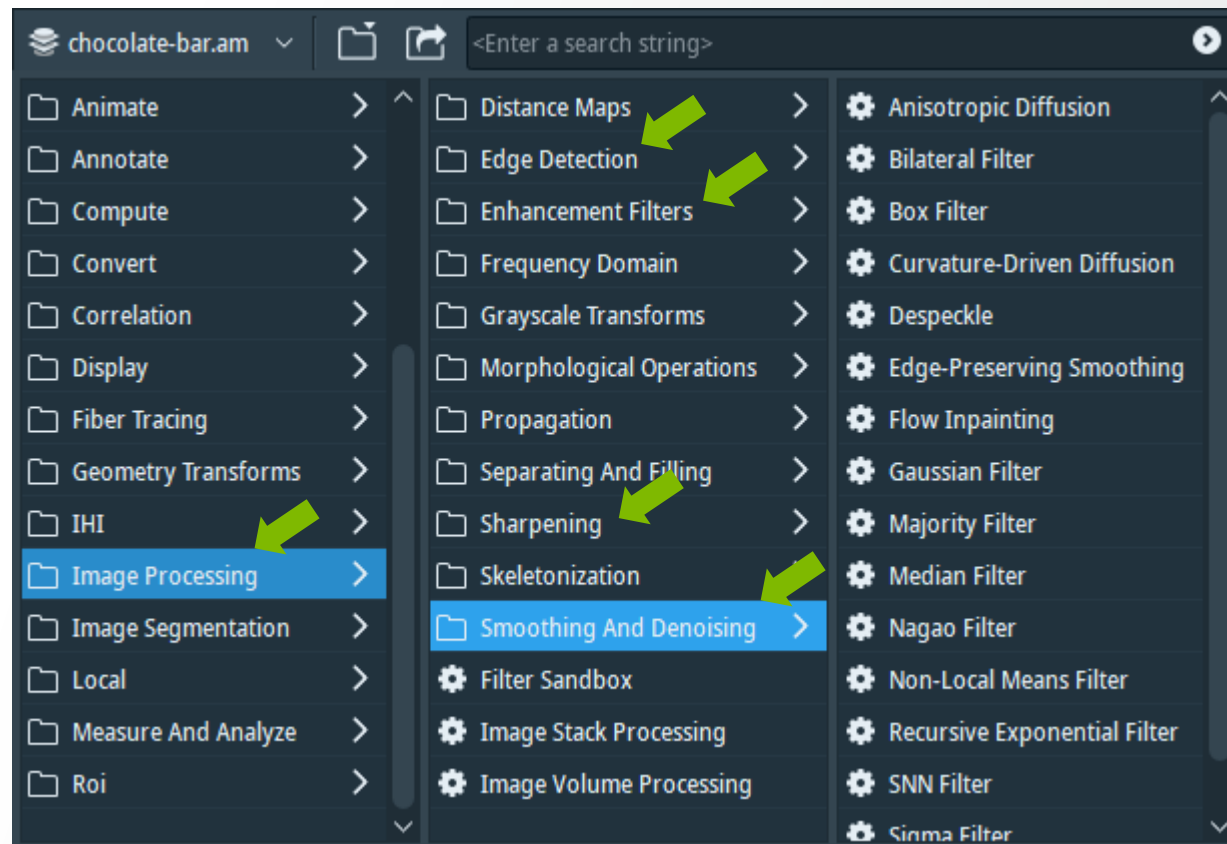


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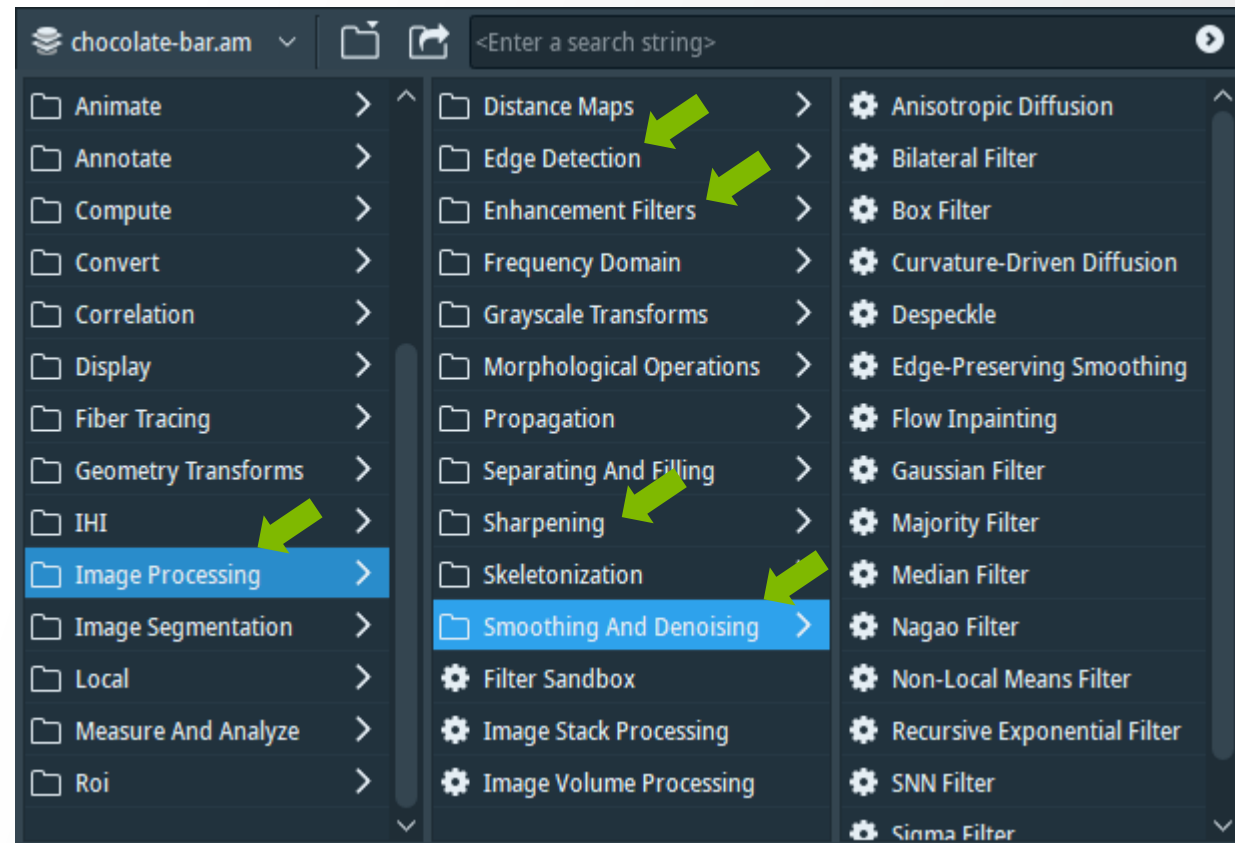


Image filtering: how to apply a filter in Avizo

Filter Sandbox module allows testing different filters in order to make the best choice for a given dataset:

- Select a filter
- Tune its parameters
- Apply result on a sub-volume of the dataset (useful for large datasets)

E.g. **Anisotropic Diffusion**

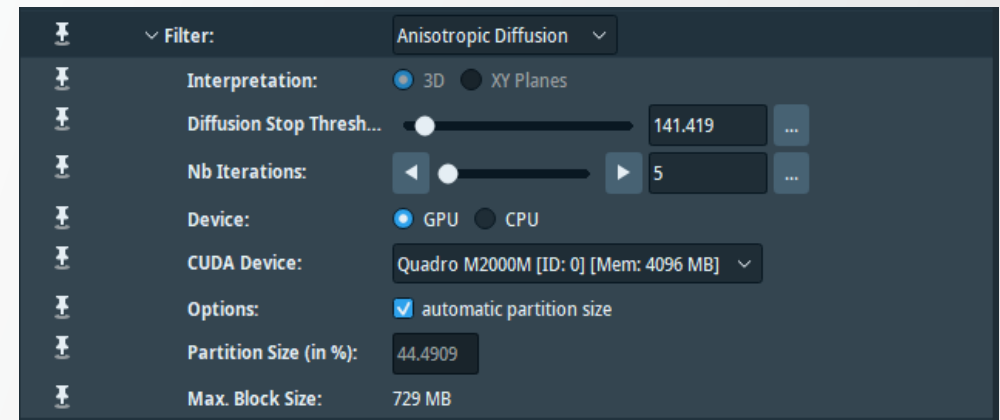
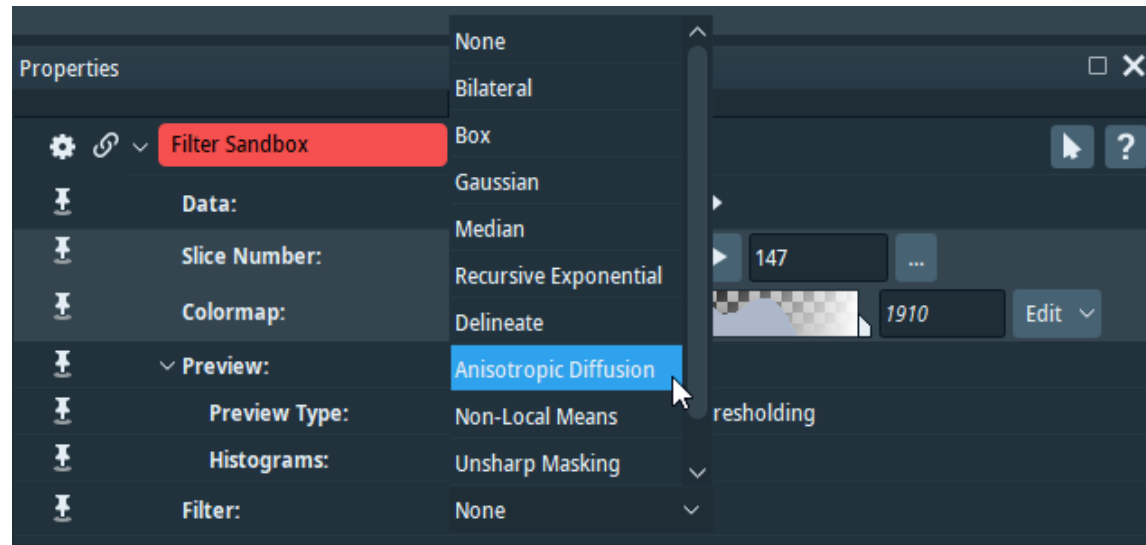
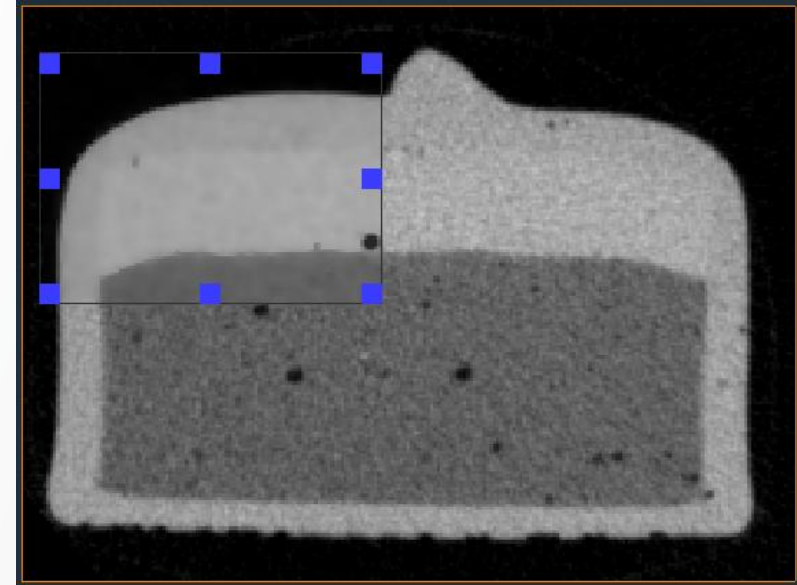


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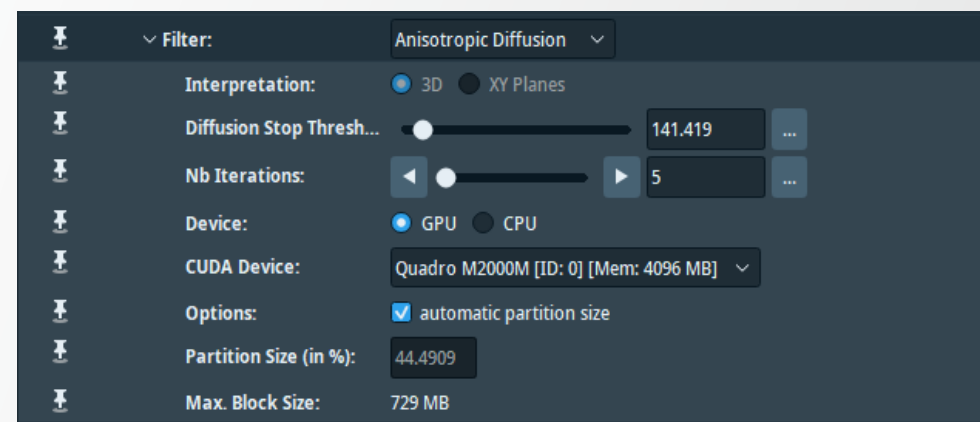
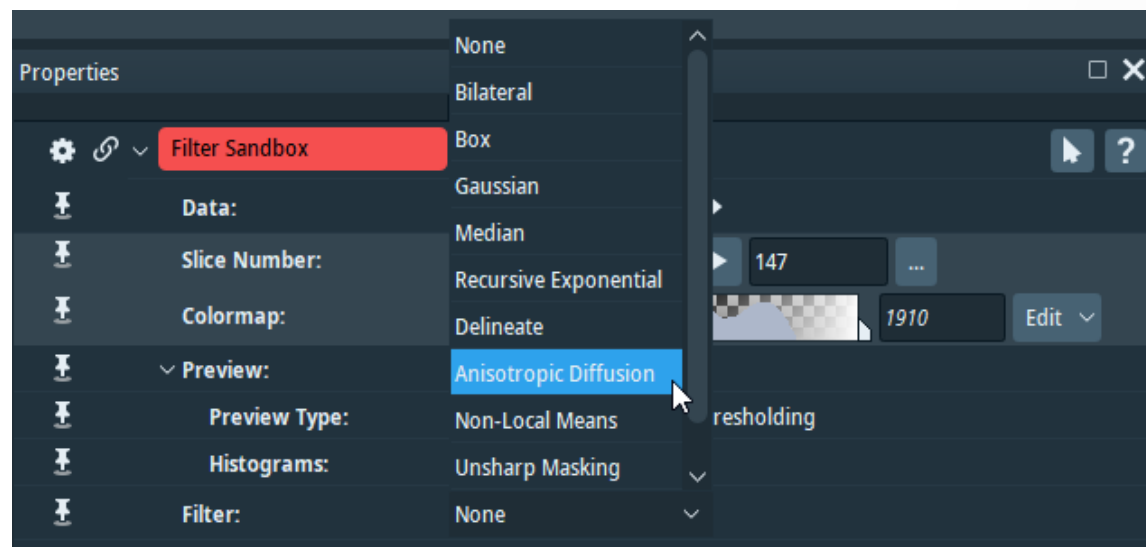
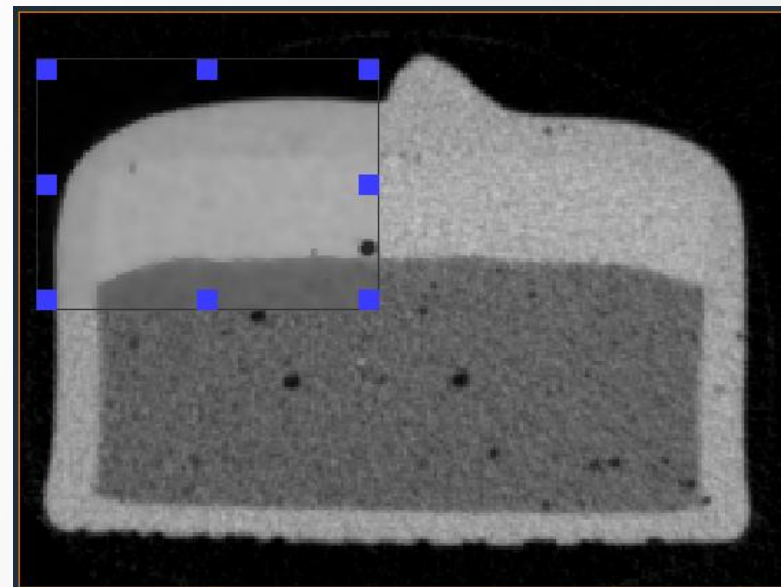


Image filtering: Box

Box Filter performs the arithmetic mean of the pixel/voxel values in the neighborhood window

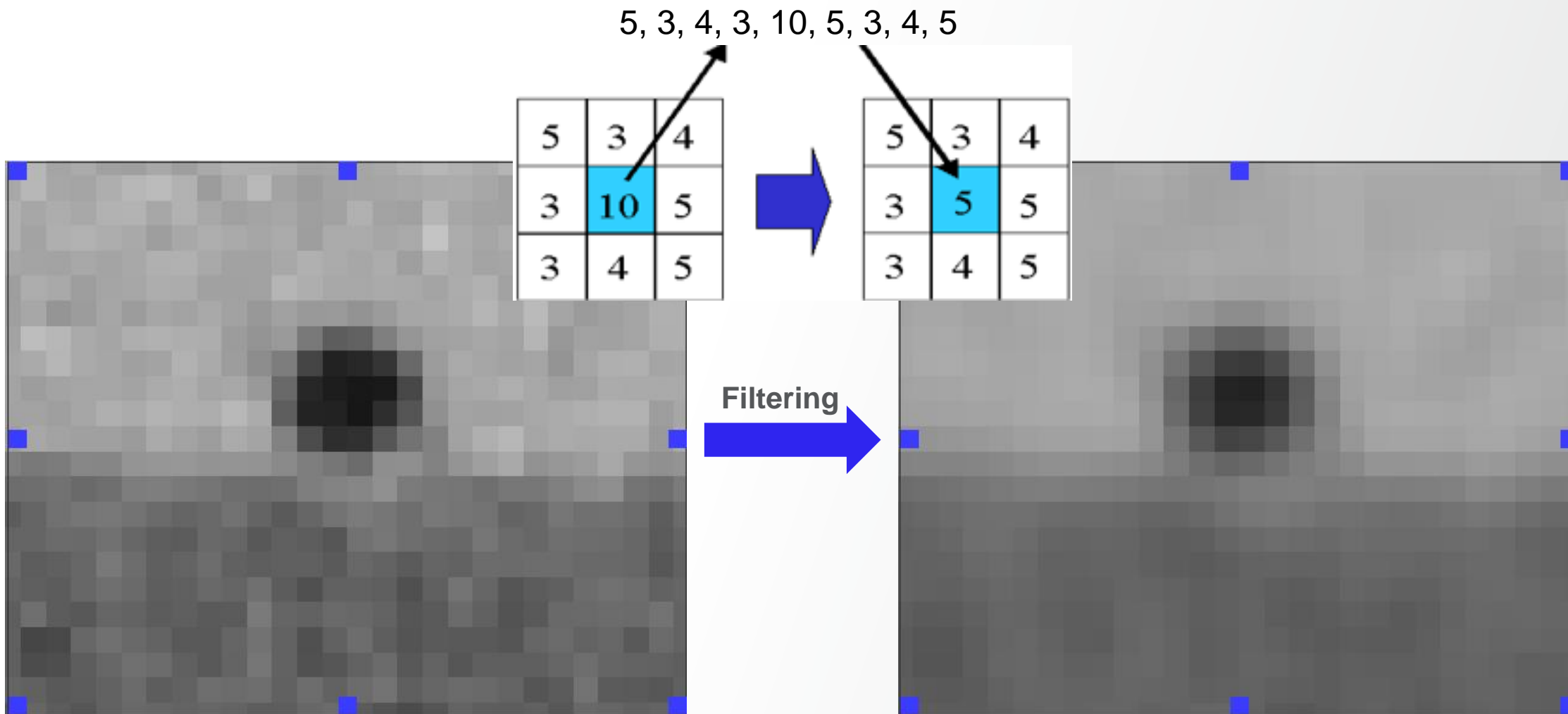


Image filtering: Median

Median Filter outputs the median value of the pixel/voxel values in the neighborhood window

3, 3, 3, 4, 4, 5, 5, 5, 10

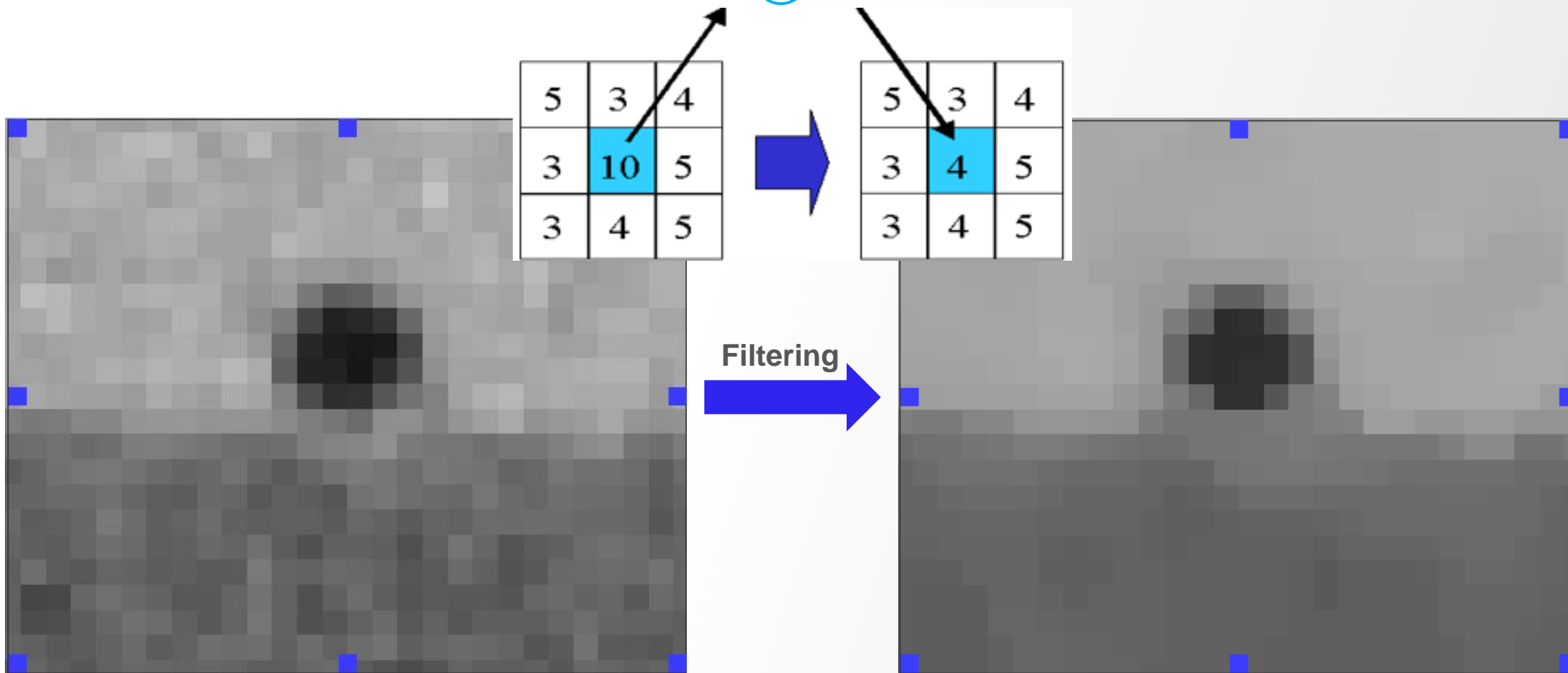


Image filtering: Non-Local Means

Non-Local Means outputs the weighted average of the values in the local neighborhood. The weight of each pixel/voxel is given by how similar its neighborhood (non-local) is to the local neighborhood.

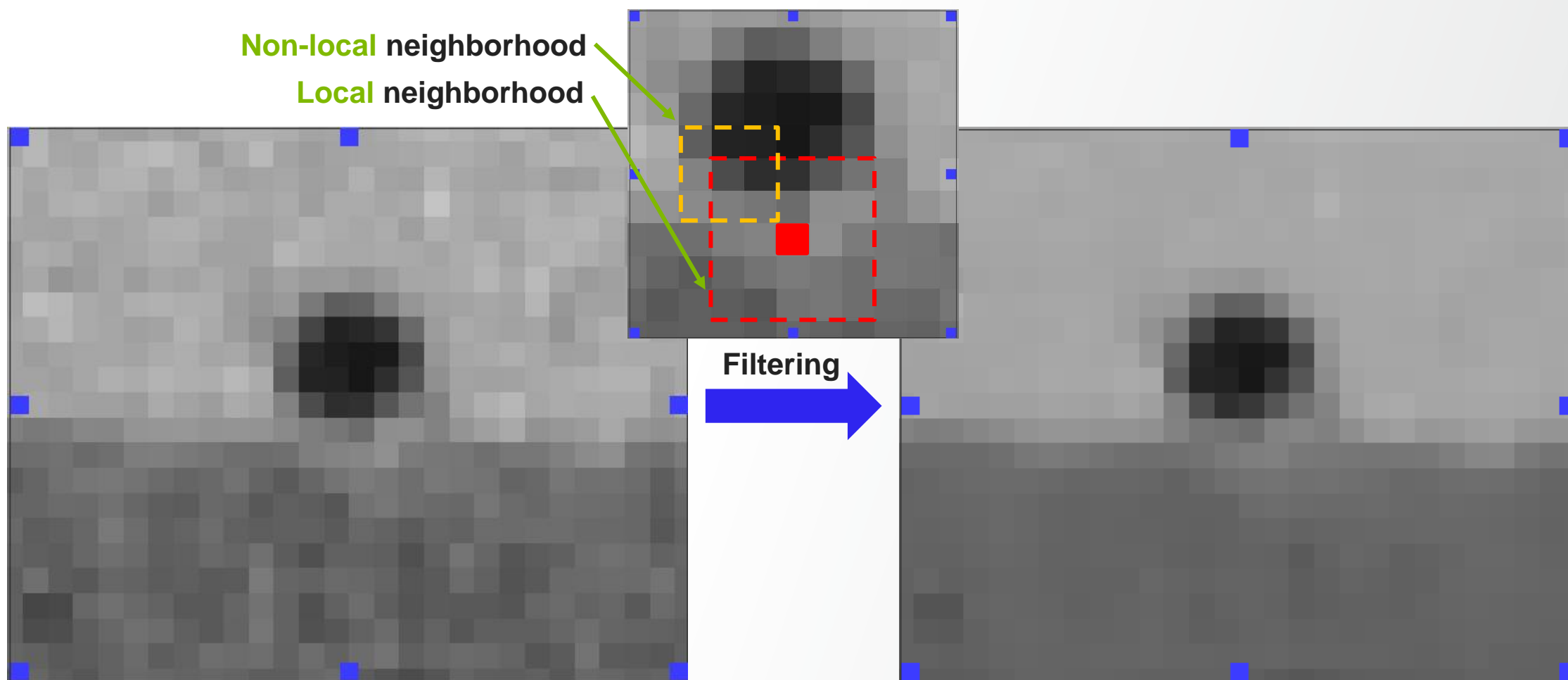
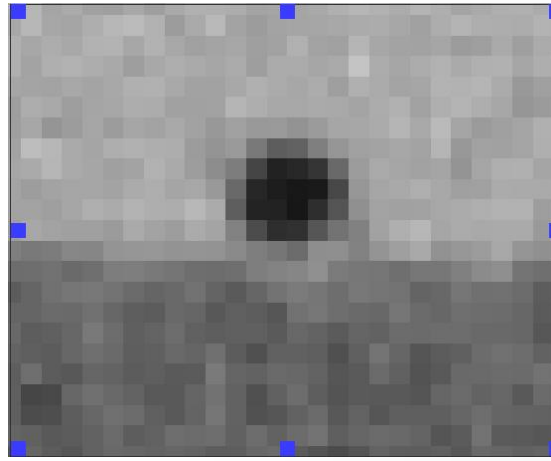
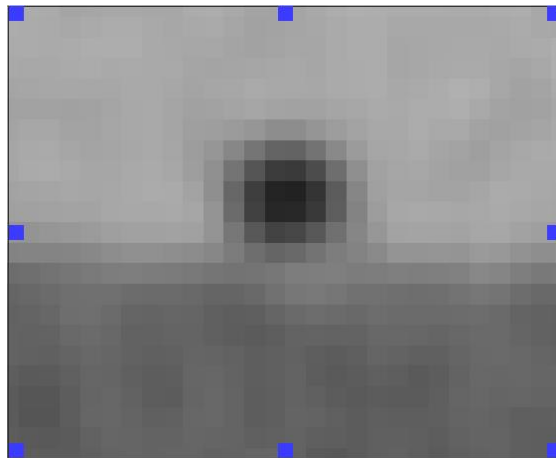


Image filtering: adapt filter choice to dataset and problem



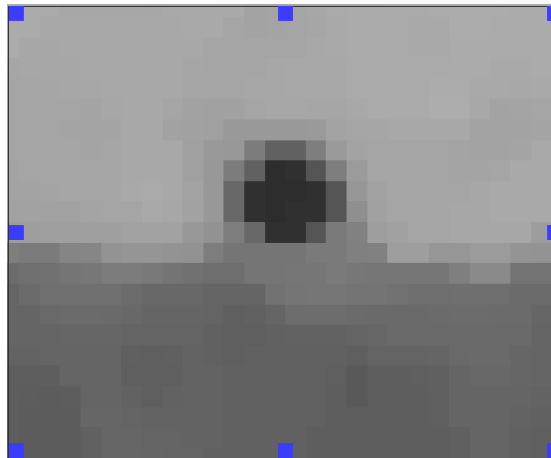
Box

Smoothing
Not edge preserving



Median

Edge preserving
but some details are lost



NLM

Edge preserving
Better preservation of details

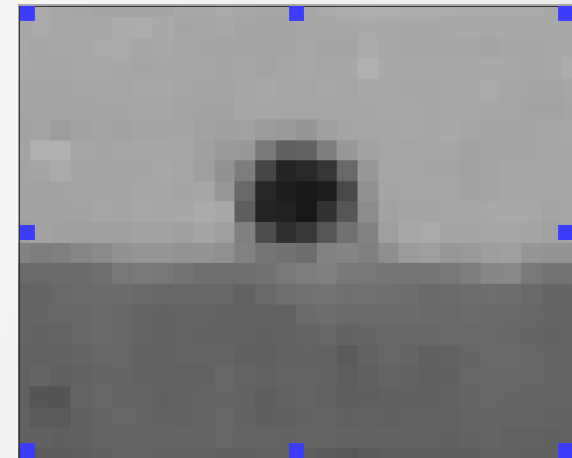
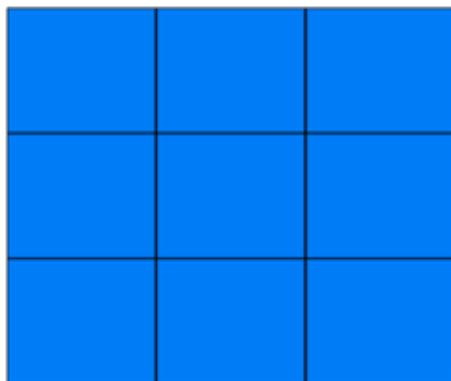


Image filtering: kernel type and connectivity

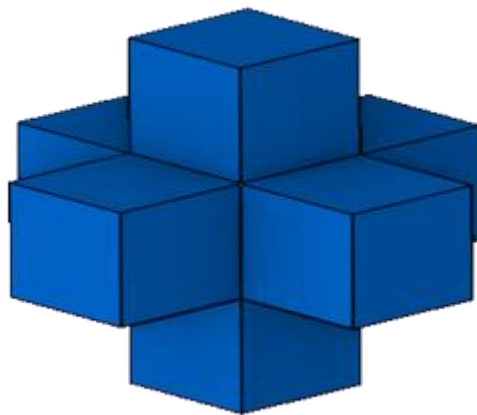
Kernel type – defines the neighborhood configuration, e.g: cube

2D

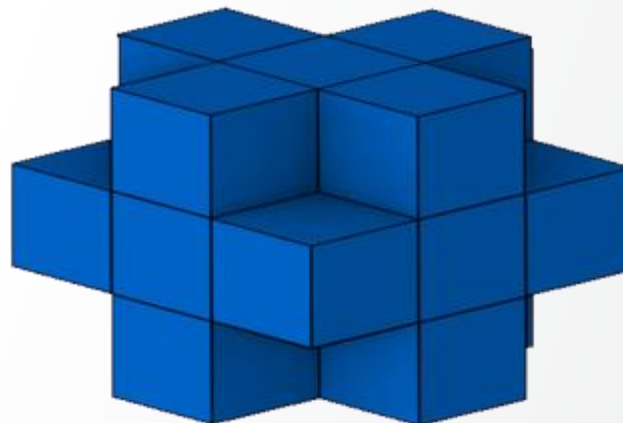


Kernel connectivity in 3D (for a cube kernel)

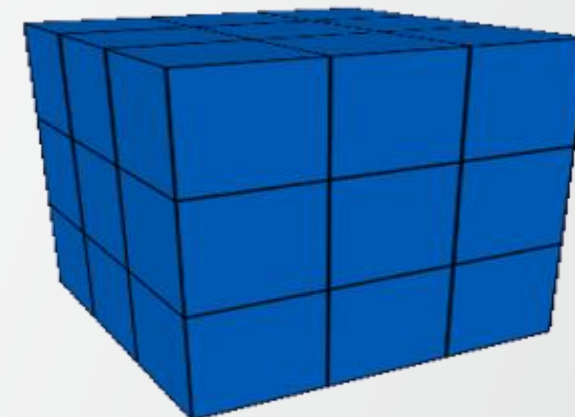
3D



6 voxels



18 voxels

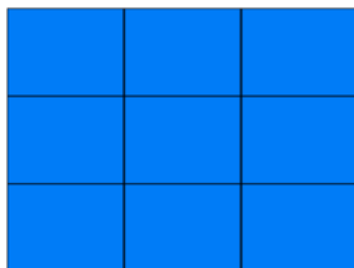


26 voxels

Image filtering: kernel size

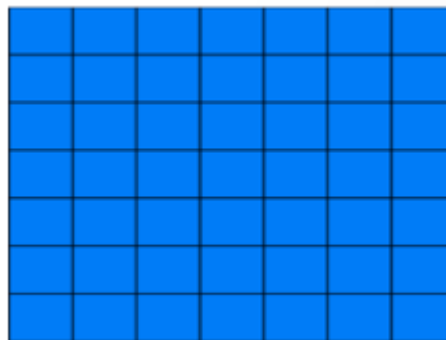
Kernel size – refers to the half kernel. Example for a cube type kernel:

Size 1

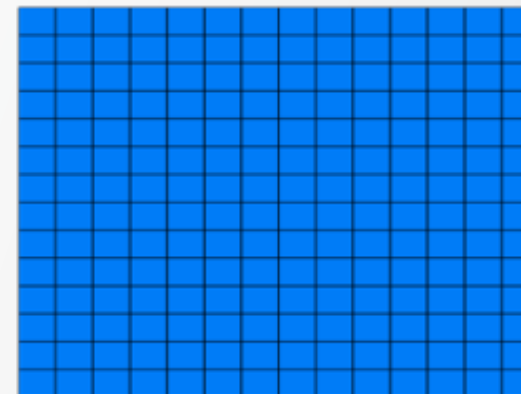


2D

Size 3



Size 6



3D

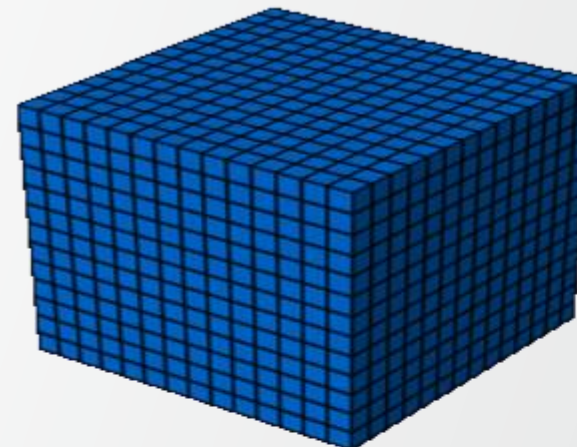
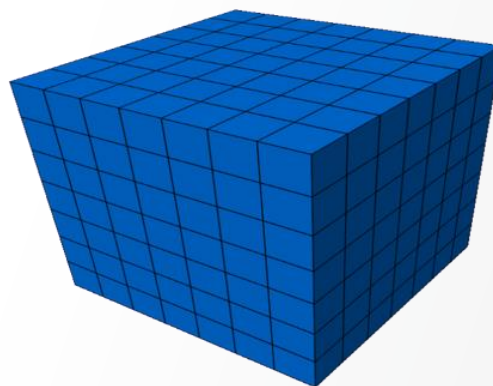
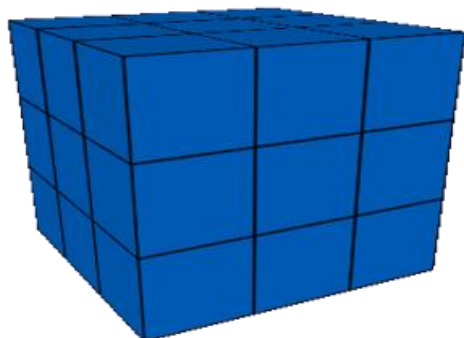
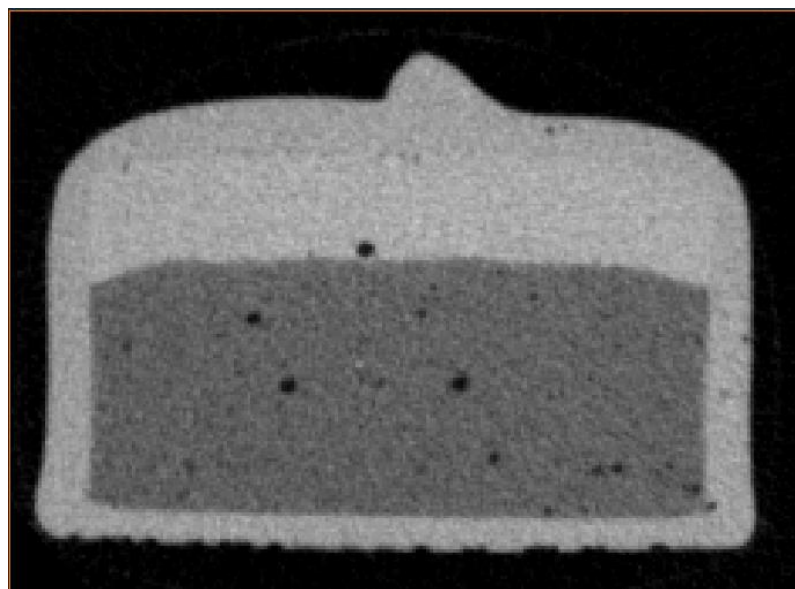


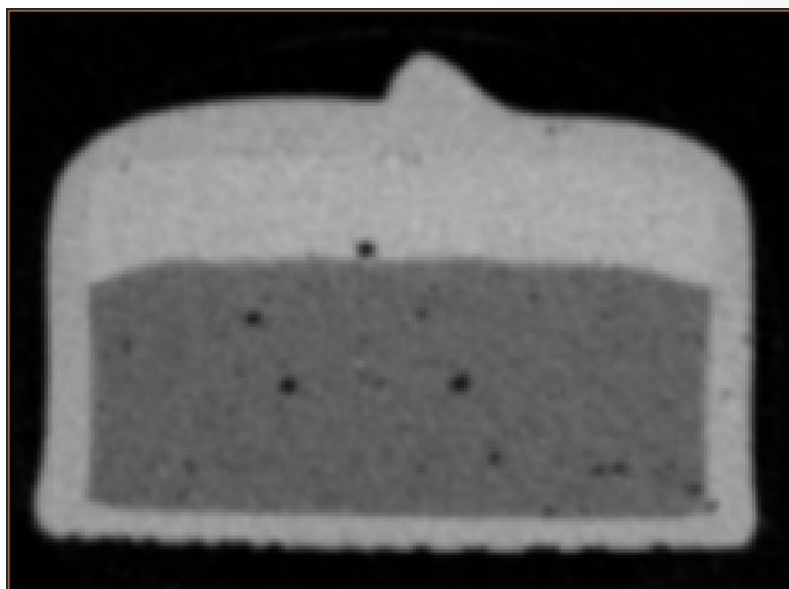
Image filtering: denoising filters

Examples of filters for removing “salt and pepper noise” (white and black dots on the image):

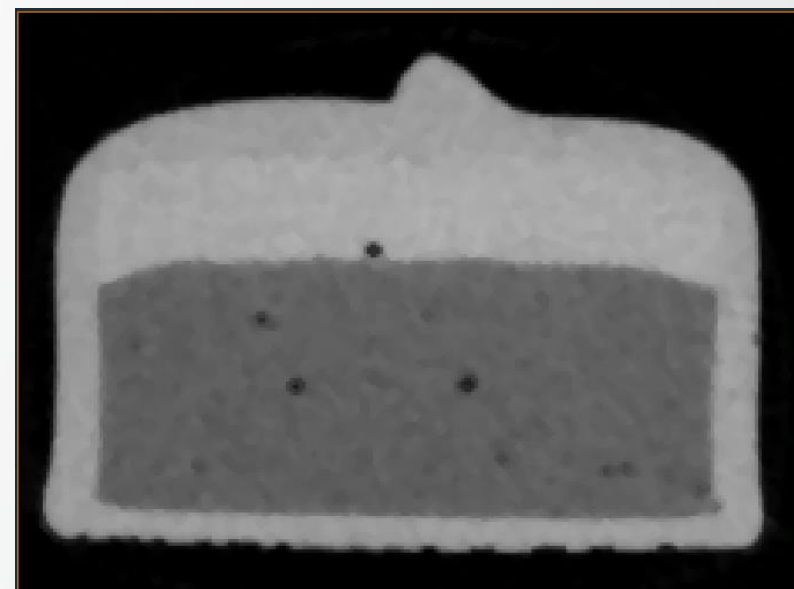
- **Gaussian** – smoothing, not effective for removing high contrast local noise
- **Median** – fast and efficient but tends to remove small details and to blur the result



Input



Gaussian

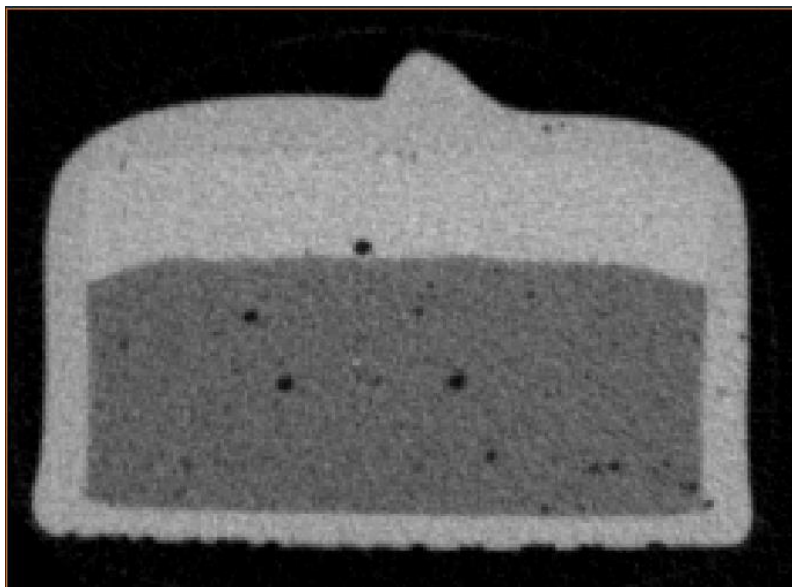


Median

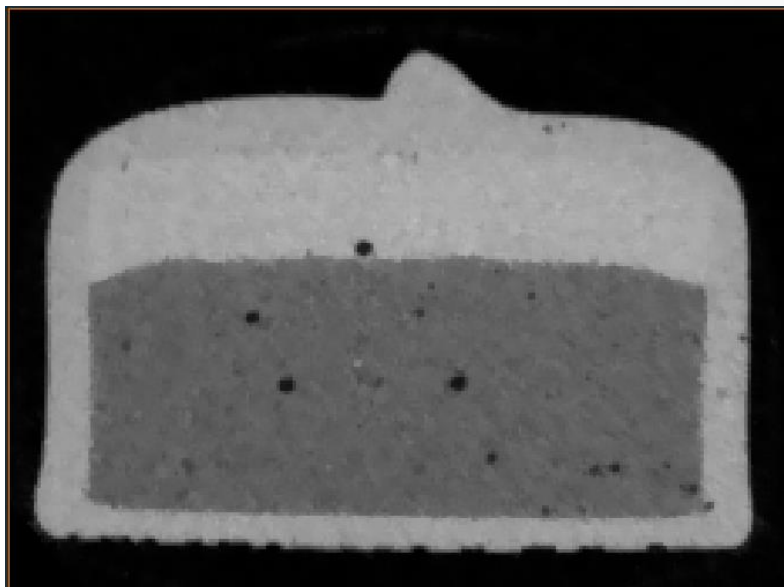
Image filtering: denoising filters

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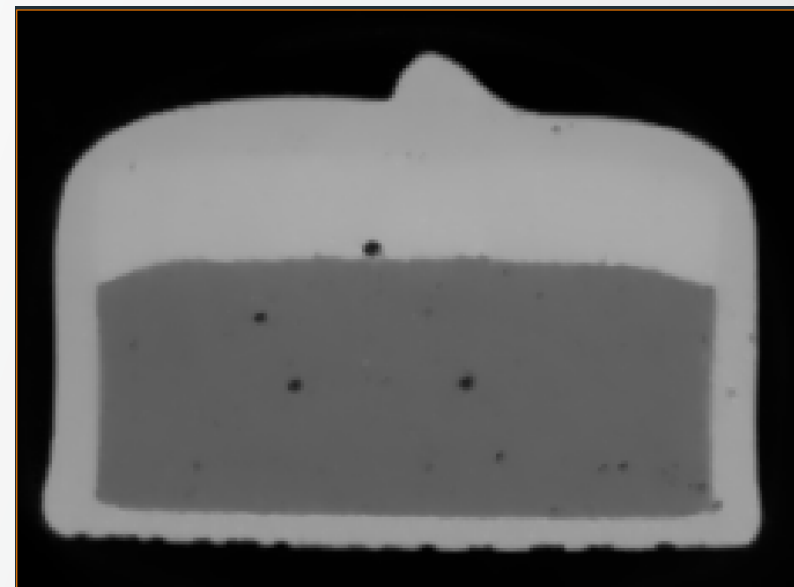
- **Bilateral** – performance in between median filter and NLM
- **Non-Local Means** – very effective at removing noise while preserving the edges but slow



Input



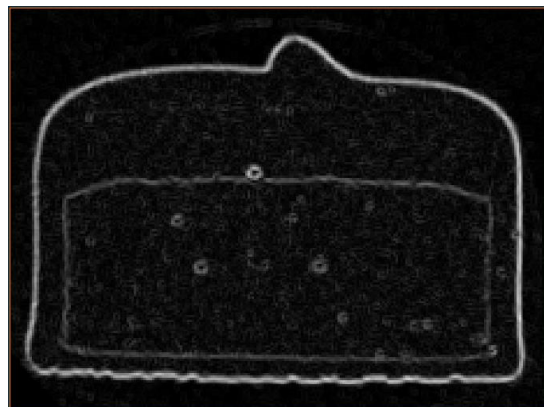
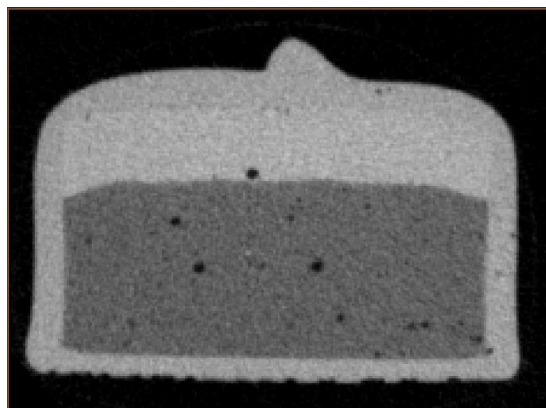
Bilateral



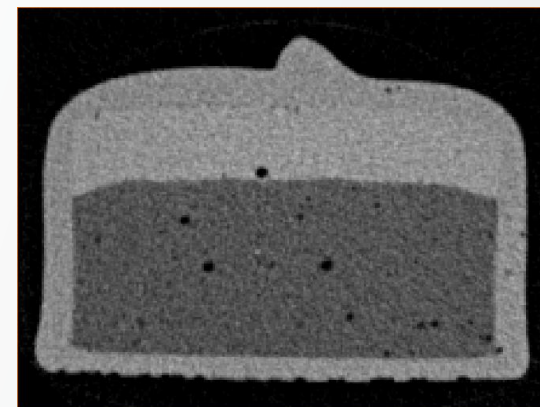
NLM

Image filtering: contour detection and enhancement

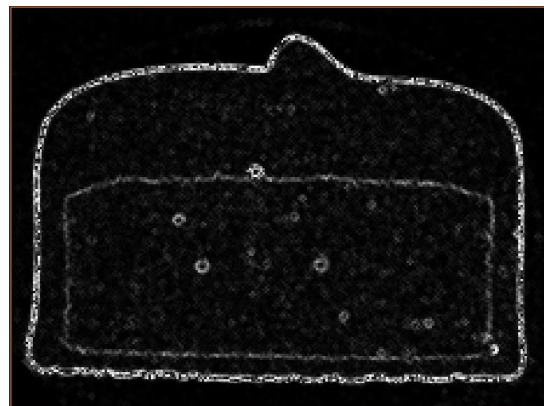
- **Sobel** and **Moments** (e.g. variance, kurtosis) – edge detection filters
 - **Unsharp Masking** – edge enhancement filter
- Best practice: employ unsharp masking after denoising



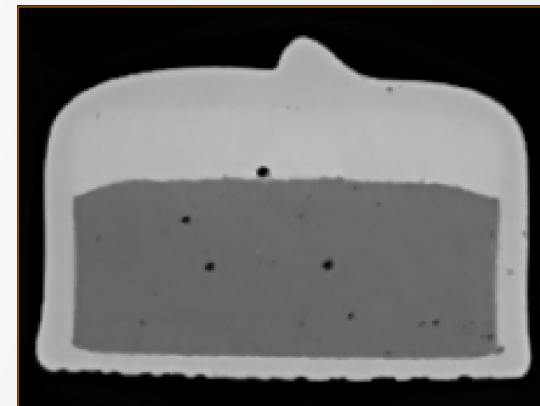
Sobel



Unsharp
Masking



Moments



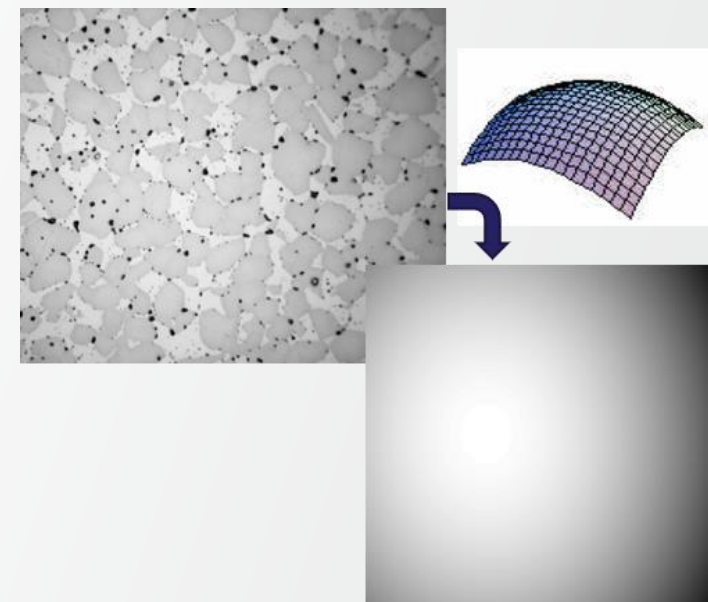
NLM +
Unsharp
Masking

Background correction

Basic idea: **remove low frequencies in image**

Can be done in Avizo by means of different modules:

- **Correct Z Drop:**
fits an arbitrary function of z to the average intensity in each slice
- **Block Face Correction:**
matches masked-slice average intensity to volume average intensity
- **Background Image:**
estimates background image, slice by slice, by fitting a 2nd order polynomial (to the masked region)
- **Shading correction wizard:**
removes image low frequency by dividing the input image by a background image
- **Background Detection Correction:**
estimates the background from a B-spline model (for example) with specified grid and removes it.



Background correction

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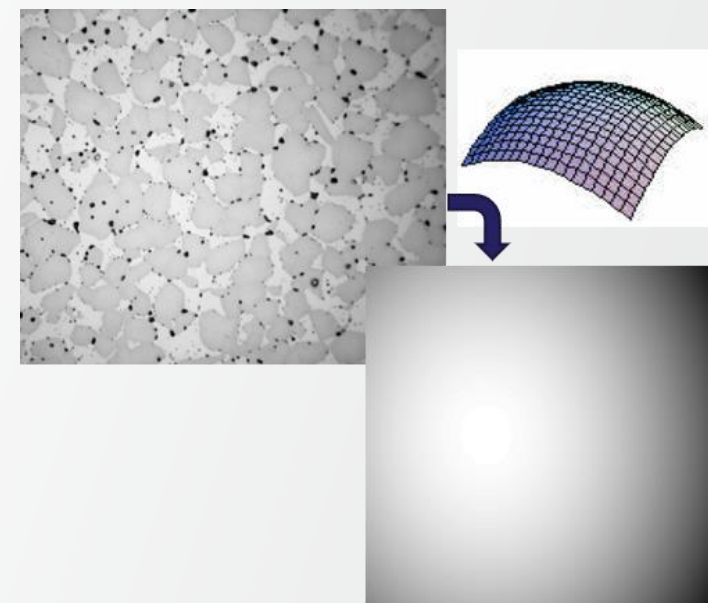
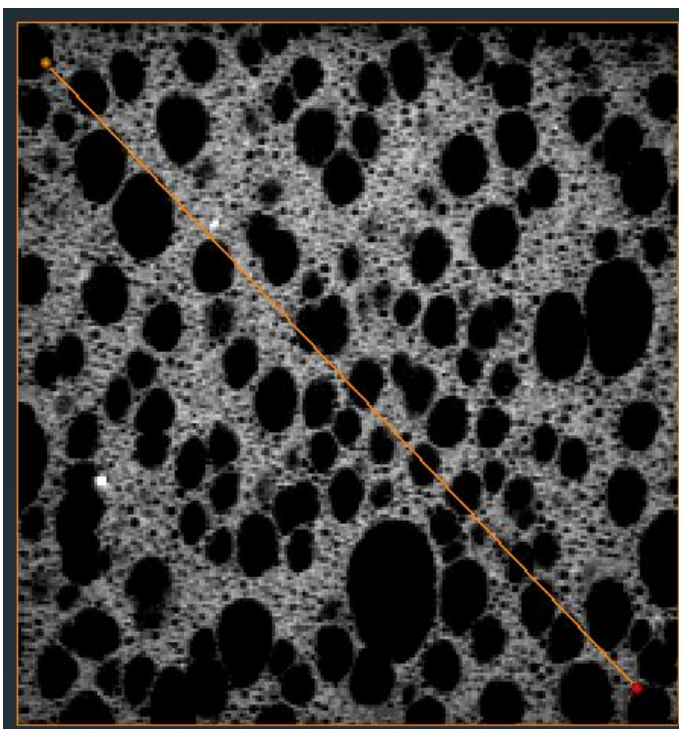


Image pre-processing: exercise 1

Background correction

Apply a background correction method in order to obtain a similar result:

Original



Corrected

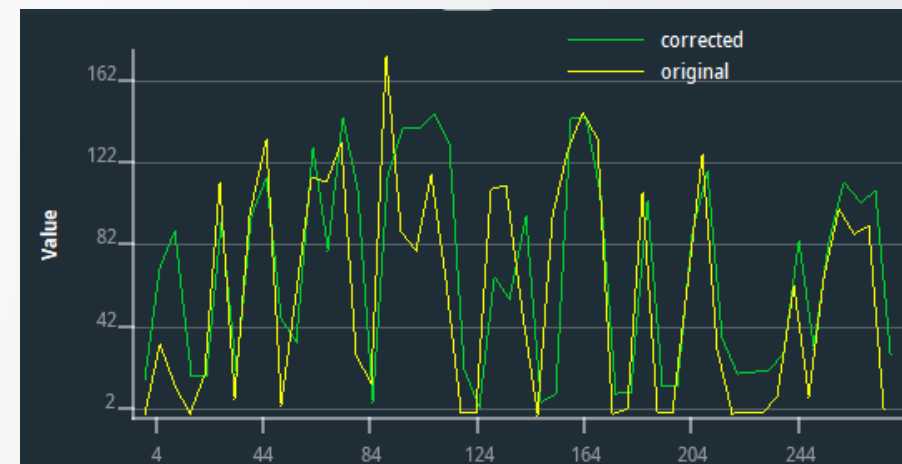
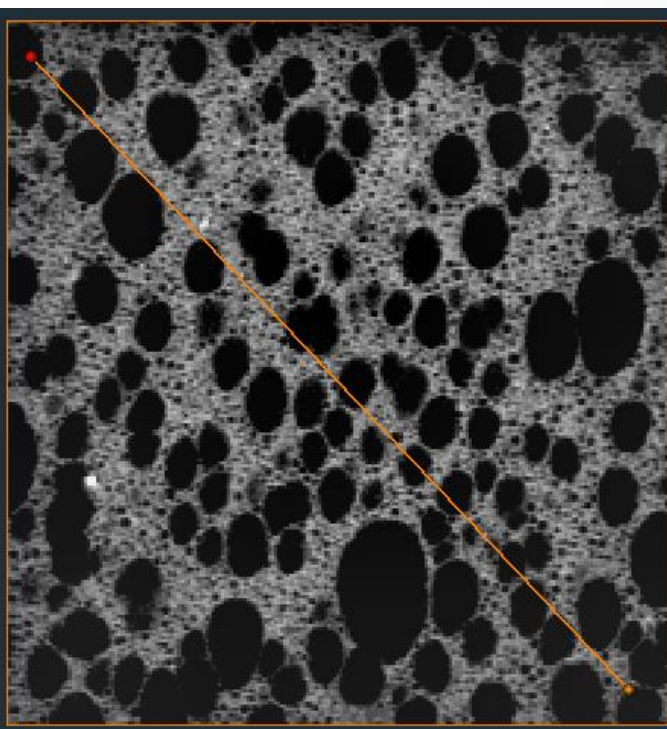


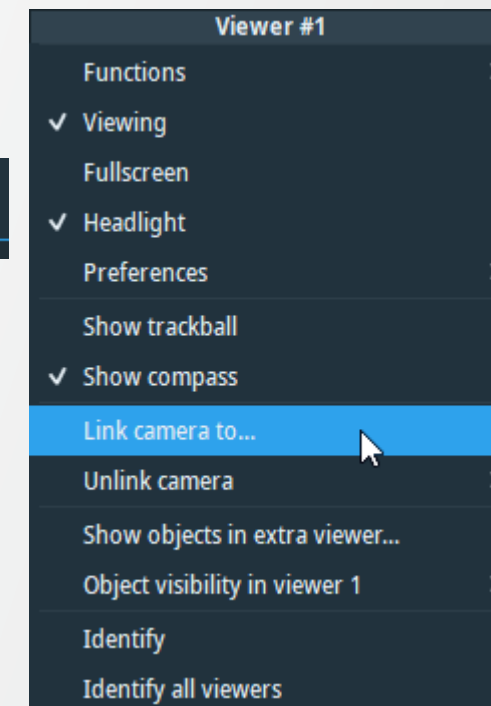
Image pre-processing: exercise 1

Solution

- Example 1: **Shading Correction Wizard**
 - Threshold 75-255
 - Normalization 130
- Example 2: **Background Detection Correction**
 - Type: B-spline
 - Size: 5, 5, 5

Tips:

- Visualization setup for comparing images:
 - Use multiple viewers with **linked camera**
 - right-click on one of the images in the two viewers
 - select “Link camera to...”
 - then click on the image in the second viewer.
- Assess background
 - Use **Line Probe** module and increase number of samples if necessary « take average » (with increased radius / long. Width)



Introduction to frequency domain filtering

Fourier Transform

- Filters out low frequency (small intensity variations) or high frequency (strong intensity variations e.g. edges) components in images

Steps

- Compute the Fourier Transform of the image
- Multiply the images Fourier Transform by a filter function (low-pass filter, high pass-filter, etc.)
- Compute the inverse Fourier Transform of the result (the result is mapped back to the spatial domain)

Why filter in the frequency domain ?

- Can be much faster than the spatial domain filtering (a convolution in the spatial domain is replaced by a multiplication in the frequency domain).

Image filtering: FFT

Frequency domain filtering can be achieved in Avizo by means of **FFT Filter** module

FFT Filter has two main functioning modes:

- Spatial: removal of periodic structures or stripes
- Frequency: removal of periodic/directional structures and spots from the FFT magnitude (advanced-user mode)

Principal use-cases:

- Curtaining artefacts in FIB-SEM (the module's parameters are set by default for filtering vertical stripes)
- Horizontal stripes in light-sheet microscopy images

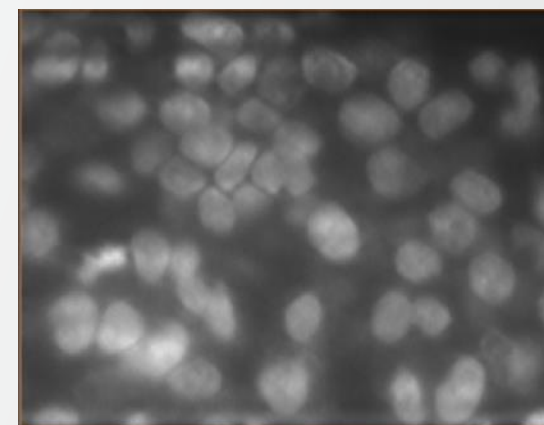
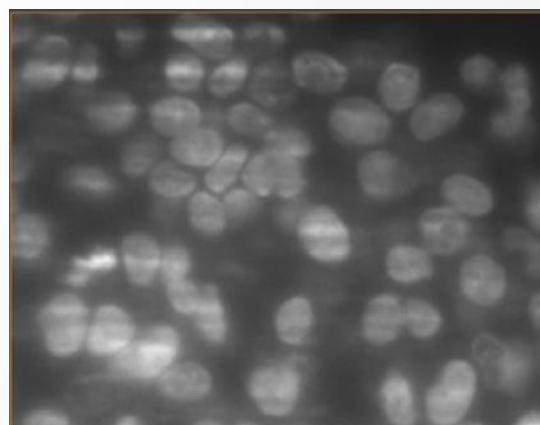
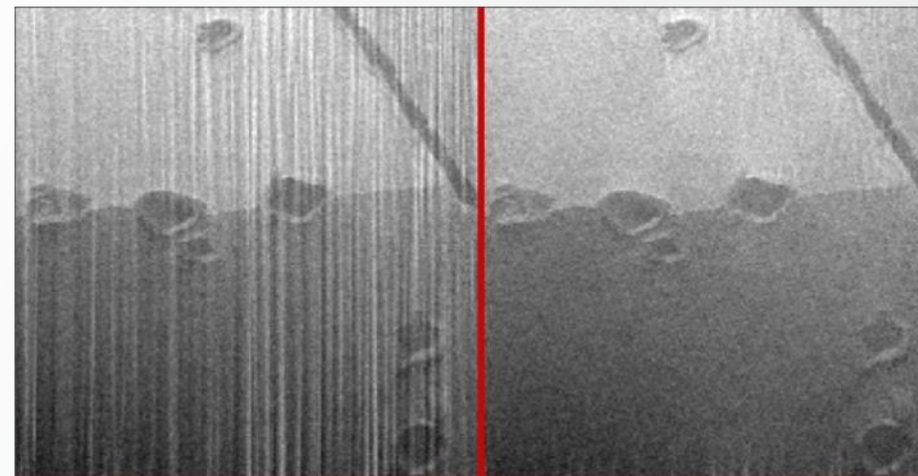
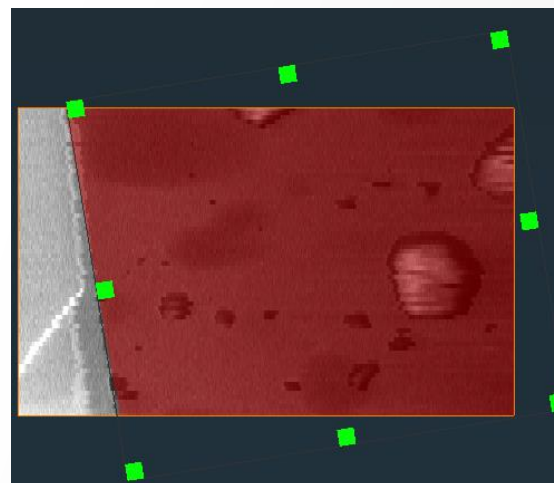


Image pre-processing: exercise 2

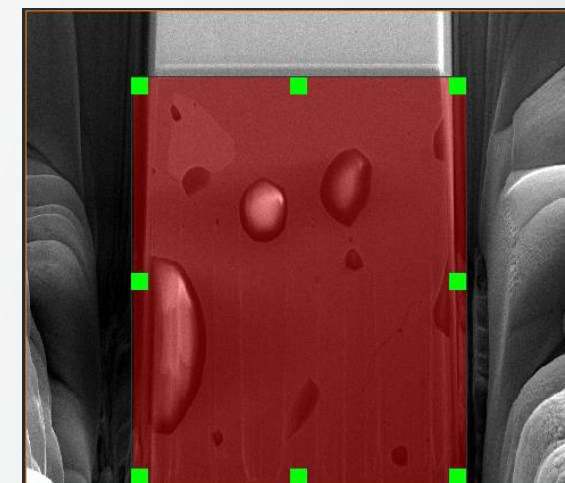
Slice Alignment

- Load fib/MoSi2-shear-corrected.am
- Use **Volume Edit** to **create a mask**
 - Use the different transformers to rotate and position a box
 - Exclude the trench and upper surface
 - Use “Cut Outside”
- Use **Align Slices** on masked image
 - Translation only
 - Automatic Least Squares Mode

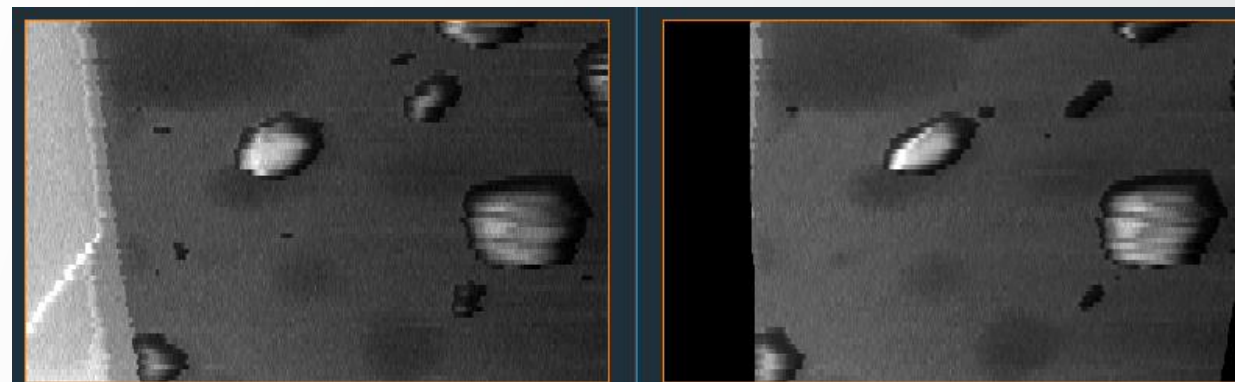
xy slice



yz slice



yz slice before and after alignment



Exercise solution:

https://youtu.be/HKh4rCr_blg

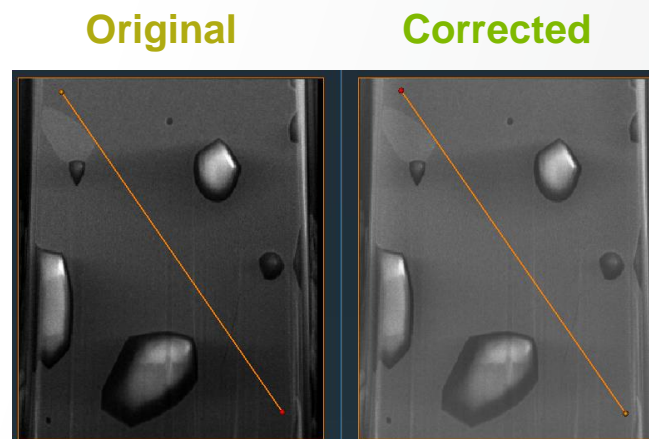
Image pre-processing: exercise 3

Background Correction, Frequency Domain Filtering, Denoising

- **Background correction**

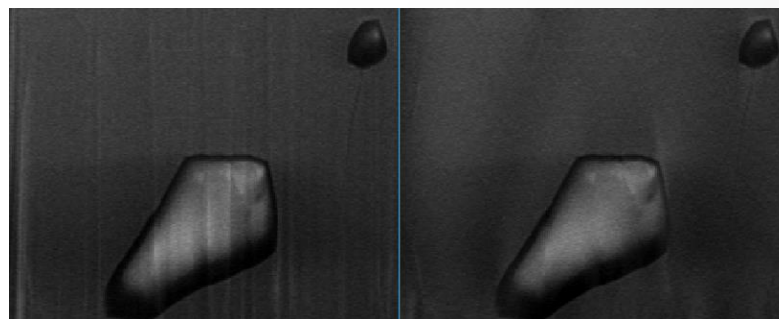
Try:

- Shading Correction Wizard
- Background Detection Correction



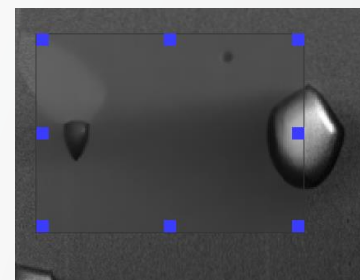
- **Reduce curtaining artefacts**

- FFT Filter



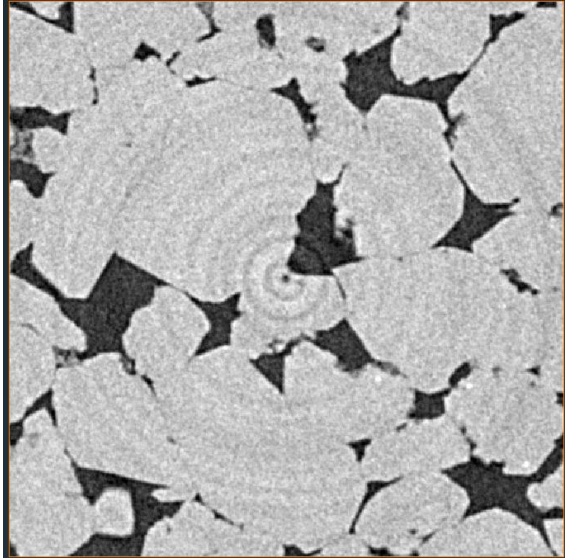
- **Denoise**

- Filter Sandbox: e.g. NLM, median, bilateral



Exercise solution: https://youtu.be/HKh4rCr_blg

Ring Artefact Removal

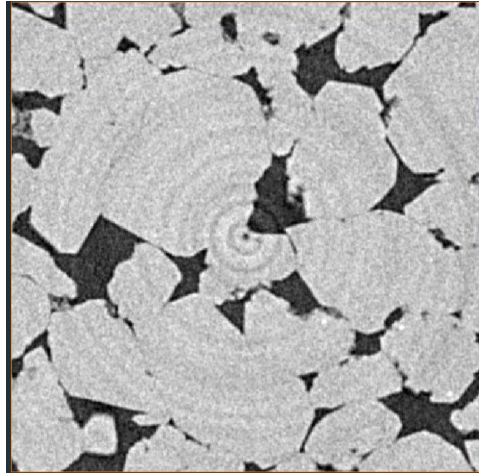


- Adjusts the mean intensity of the pixels of concentric rings to the mean intensity of the whole image
- The rotation axis is assumed to be aligned to the Z-axis of the data-set's local coordinate system
- The center of the rings needs to be adjusted manually if: the center of the image \neq the center of rotation during CT acquisition
- Using the settings "Lower Threshold" and "Upper Threshold", the calculation of the mean values can be restricted to a certain intensity interval. This might be necessary:
 - For objects with inhomogeneous density (large pores, multi-material, etc.)
 - For a geometry deviating from a cylinder
 - If a cylindrically shaped object was measured de-centered.
- The input data-type must be 16-bit unsigned. Use "Convert Image Type" if necessary.

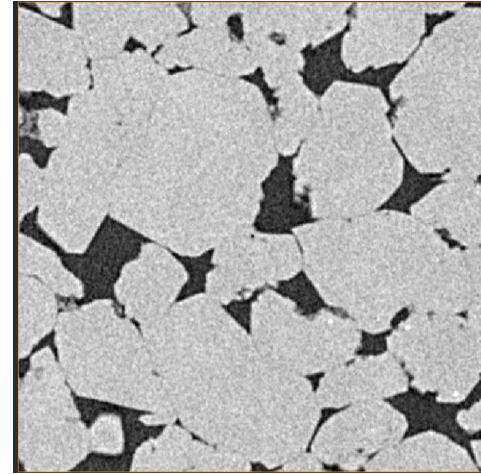
See also

Ring Artefact Removal examples:

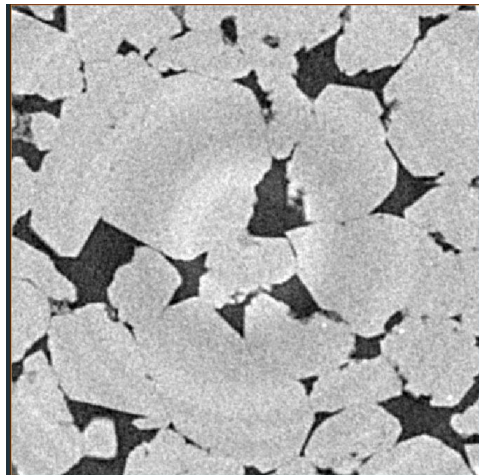
original



best correction



no intensity range
adjustment



slightly wrong
detection axis

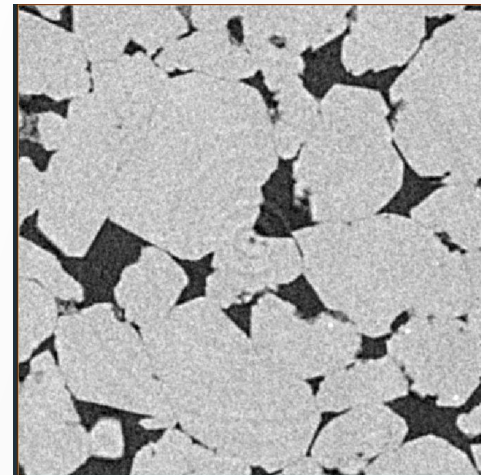


Image pre-processing: deconvolution

Image deconvolution

Iterative Maximum Likelihood Image restoration algorithm. Types of **Deconvolution**:

- Non-blind (a measured or computed PSF – *Point Spread Function* – is used)
- Blind (the PSF is estimated along with the data)

Theoretical PSF generation via **Generate Point Spread Function** module (Project View → Create Object)
PSF estimation via **Extract Point Spread Function** module (bead extraction).

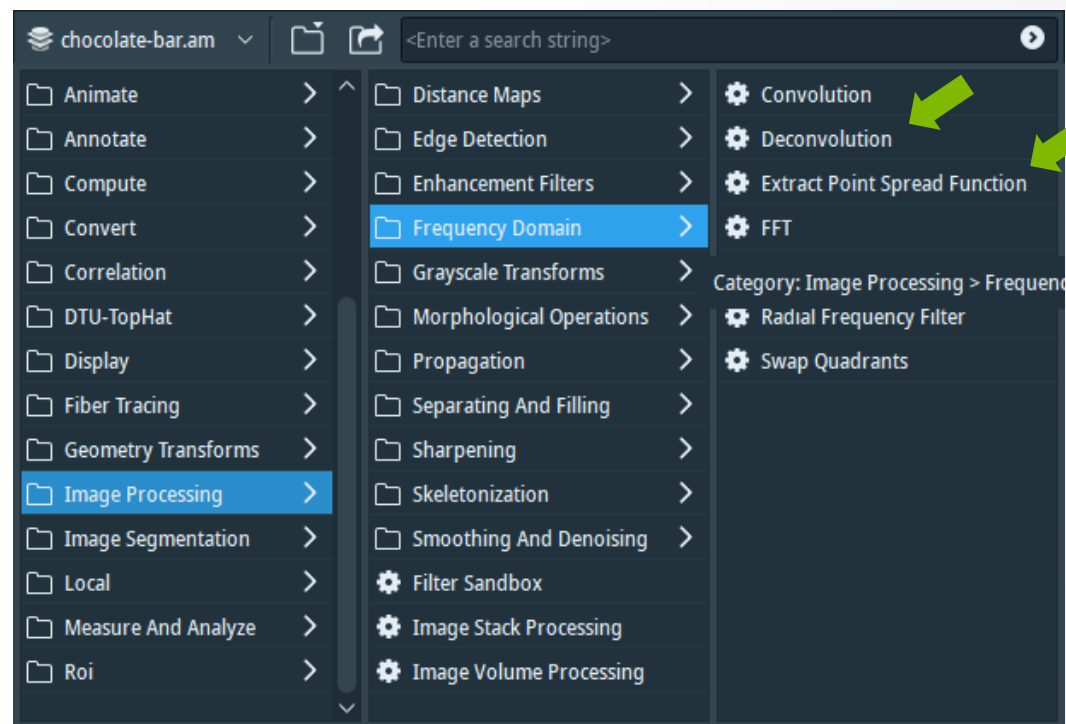


Image deconvolution: measuring the PSF

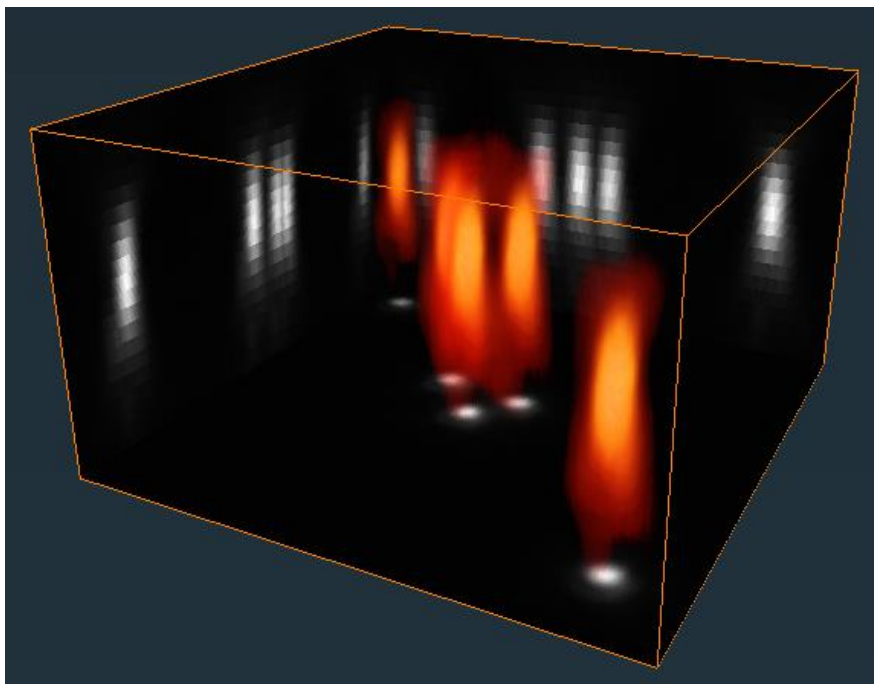
Imaging beads with desired acquisition settings (dataset available at ...data/deconv/beads.am)

Beads image visualization: **Image Ortho Projections** + **Volren**

PSF Estimation:

- **Projection Cursor** (for creating Landmarks)
- **Extract Point Spread Function** (Adjust centers + Estimate size)

Data before deconvolution



Data after estimating the PSF and applying standard deconvolution

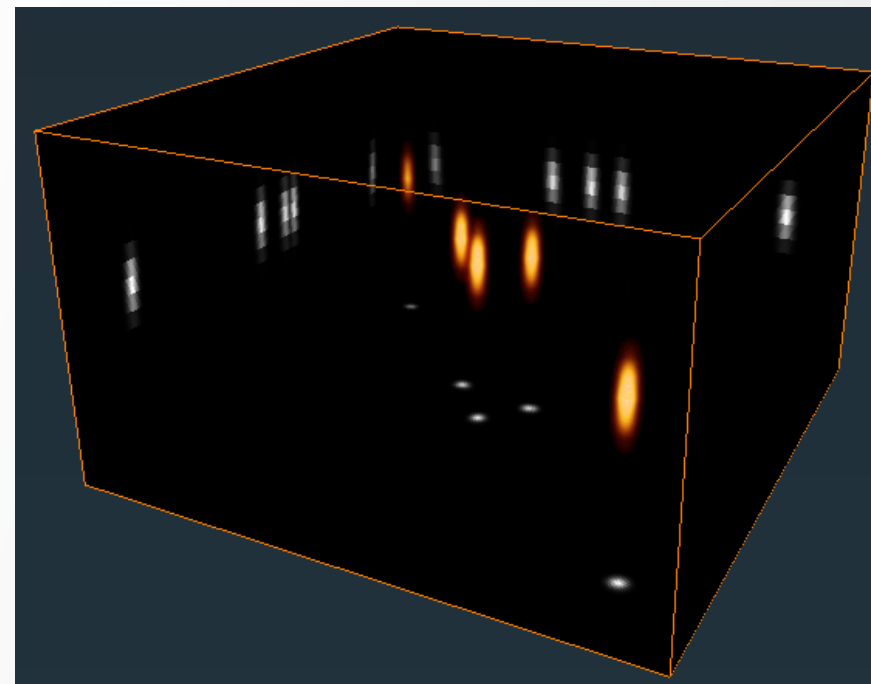
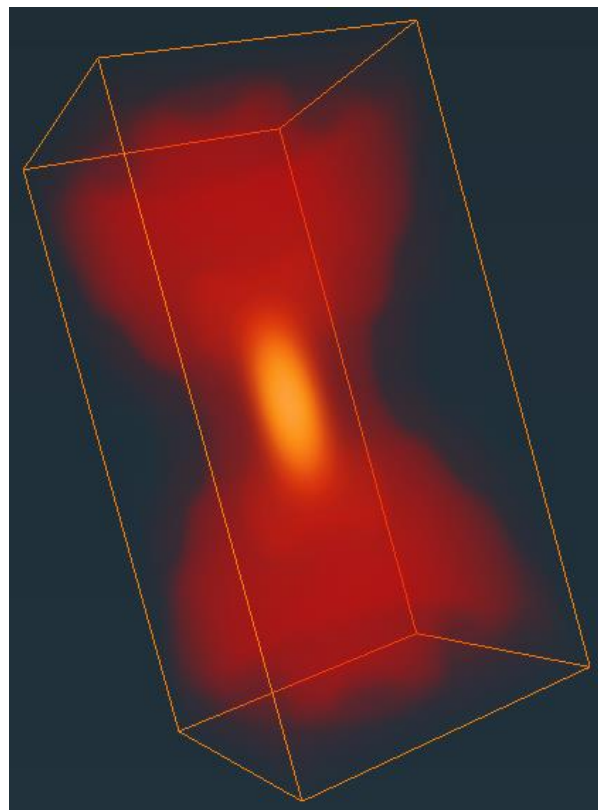


Image deconvolution: implemented mathematical PSF models

For theoretical PSF computation: **Generate Point Spread Function** module

- Choose type of microscopy: widefield or confocal
- Set microscope parameters: numerical aperture, wavelength, refractive index

Widefield



Confocal

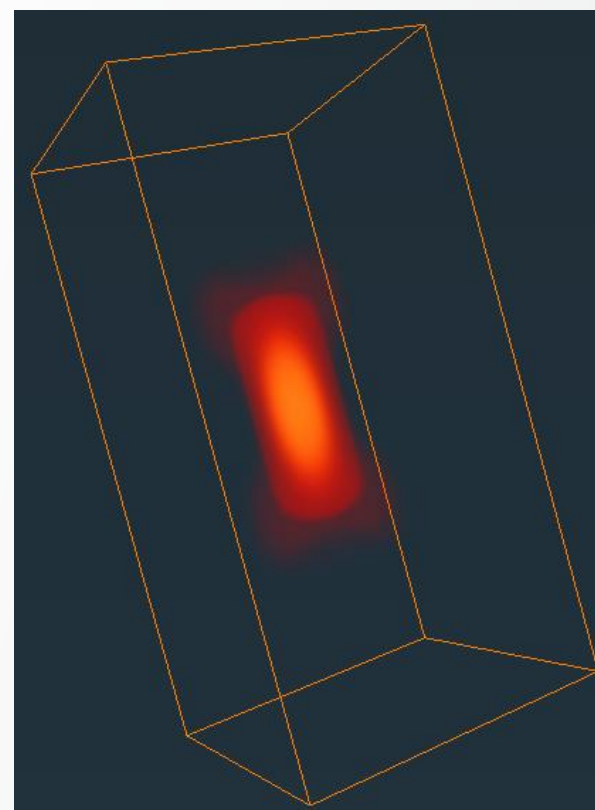


Image deconvolution: Blind method

Simultaneous data restoration and PSF estimation

- Can be initialized with a theoretical or measured PSF (that will only be used for the first iteration of the algorithm)

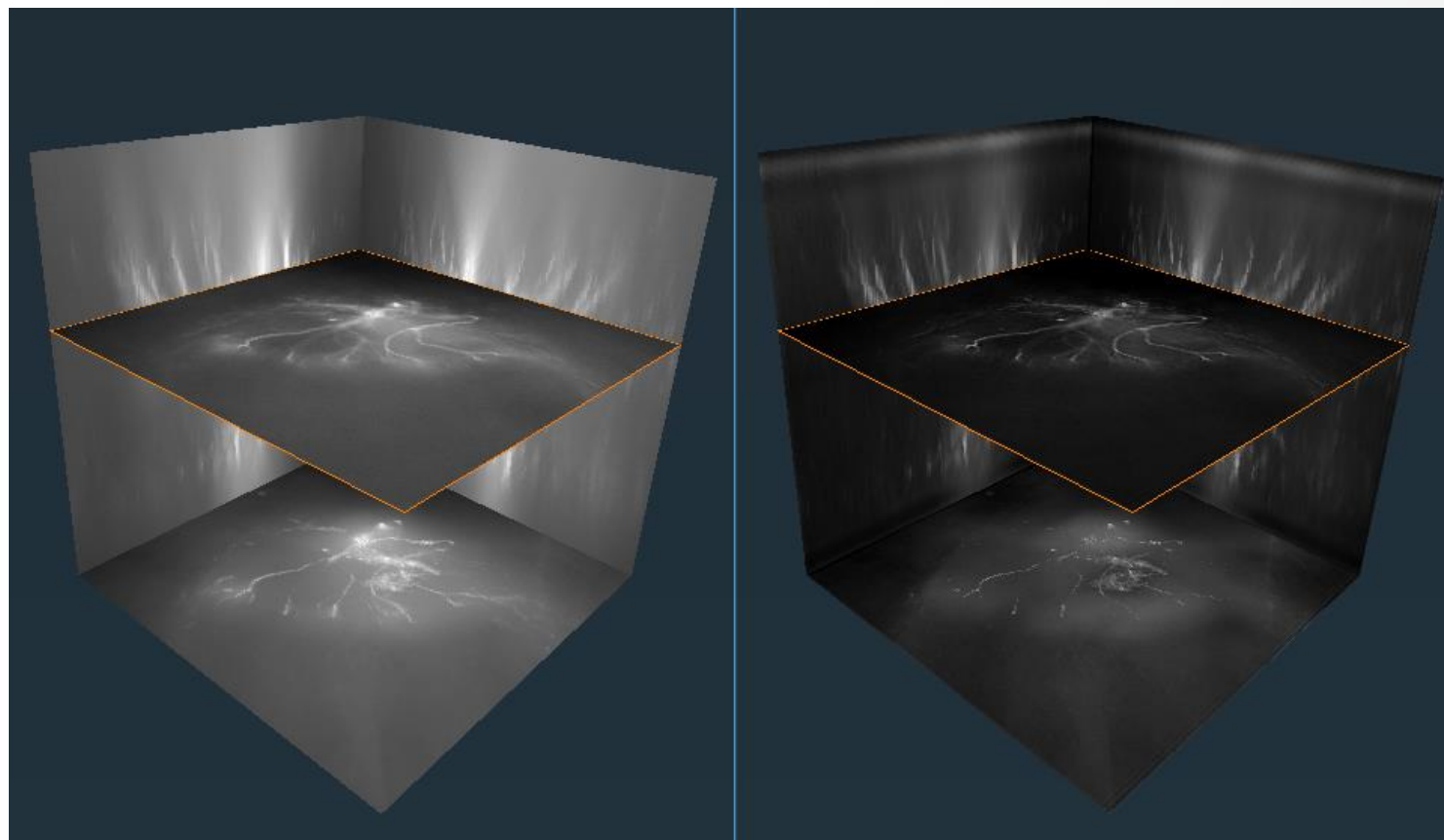


Image deconvolution: Standard method

Standard deconvolution example (dataset available at: data/deconv/polytrichum.am & polytrichum-psf.am):

- Resample PSF (optional)
- Apply Deconvolution module in standard mode

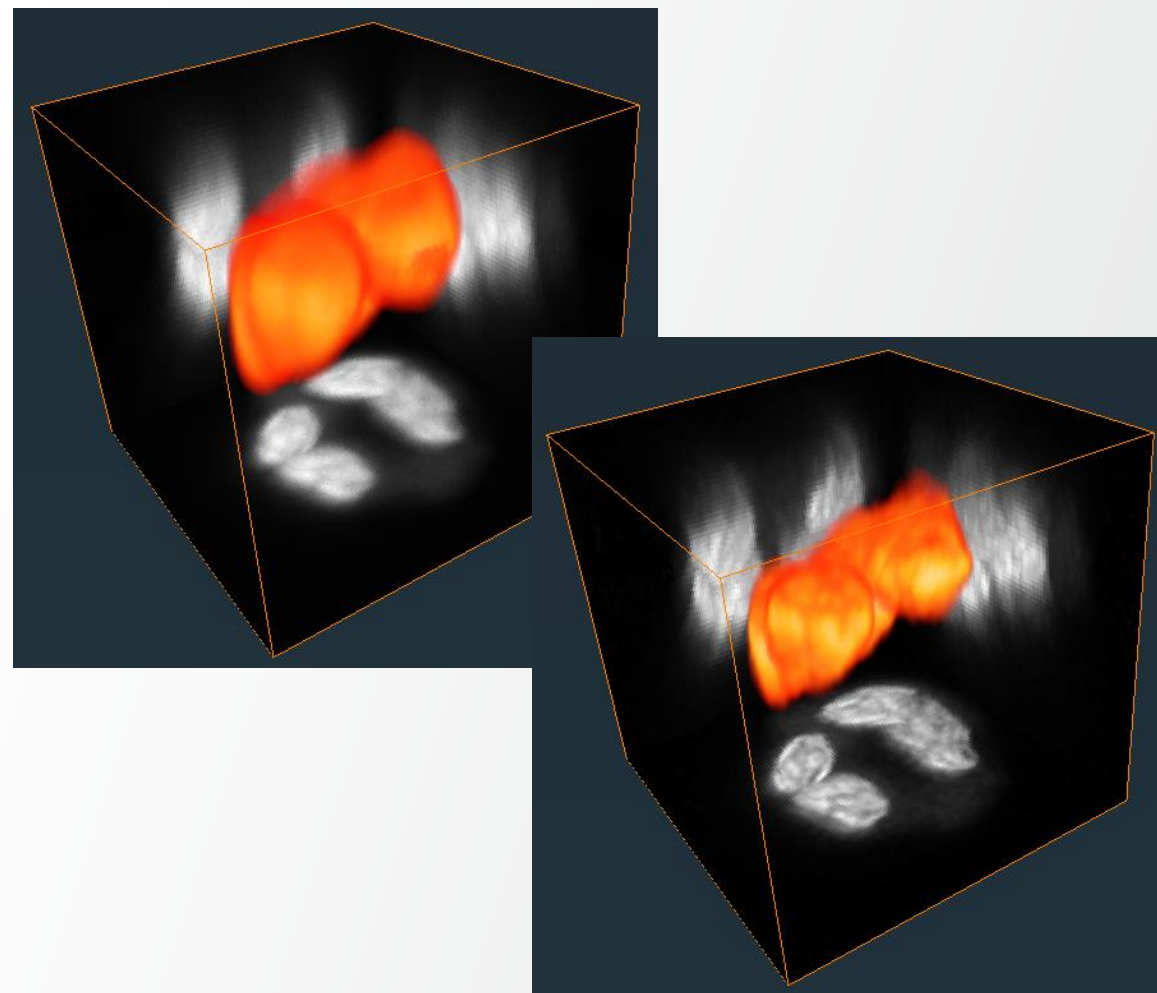
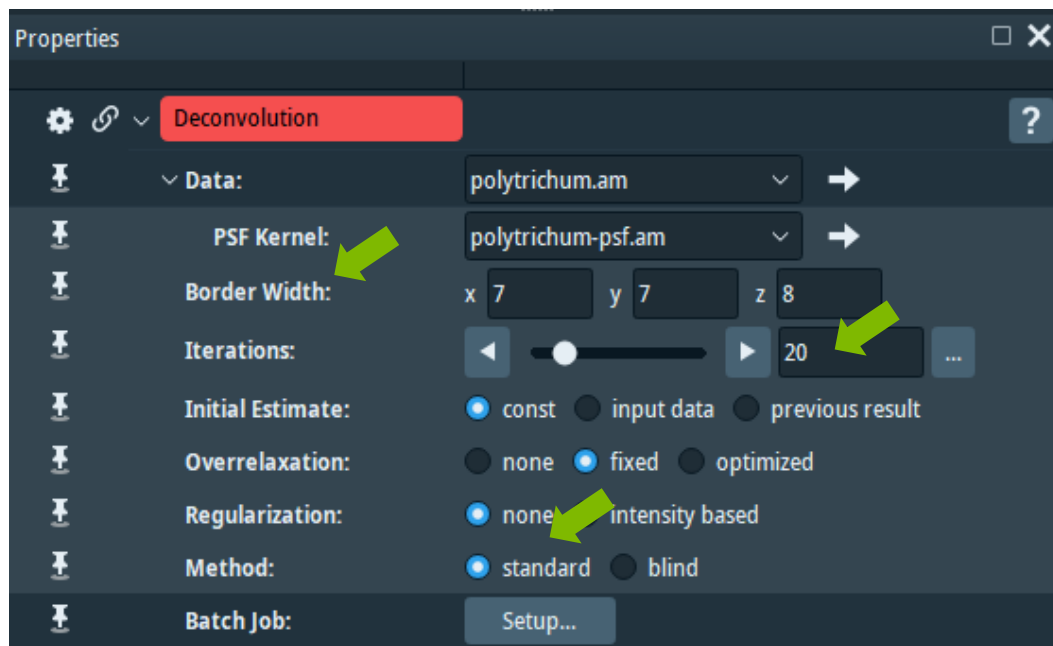


Image segmentation: Segmentation Editor

Segmentation Editor: workroom

Dedicated workroom for interactive segmentation

Tools for generating selections

Tools for editing selections

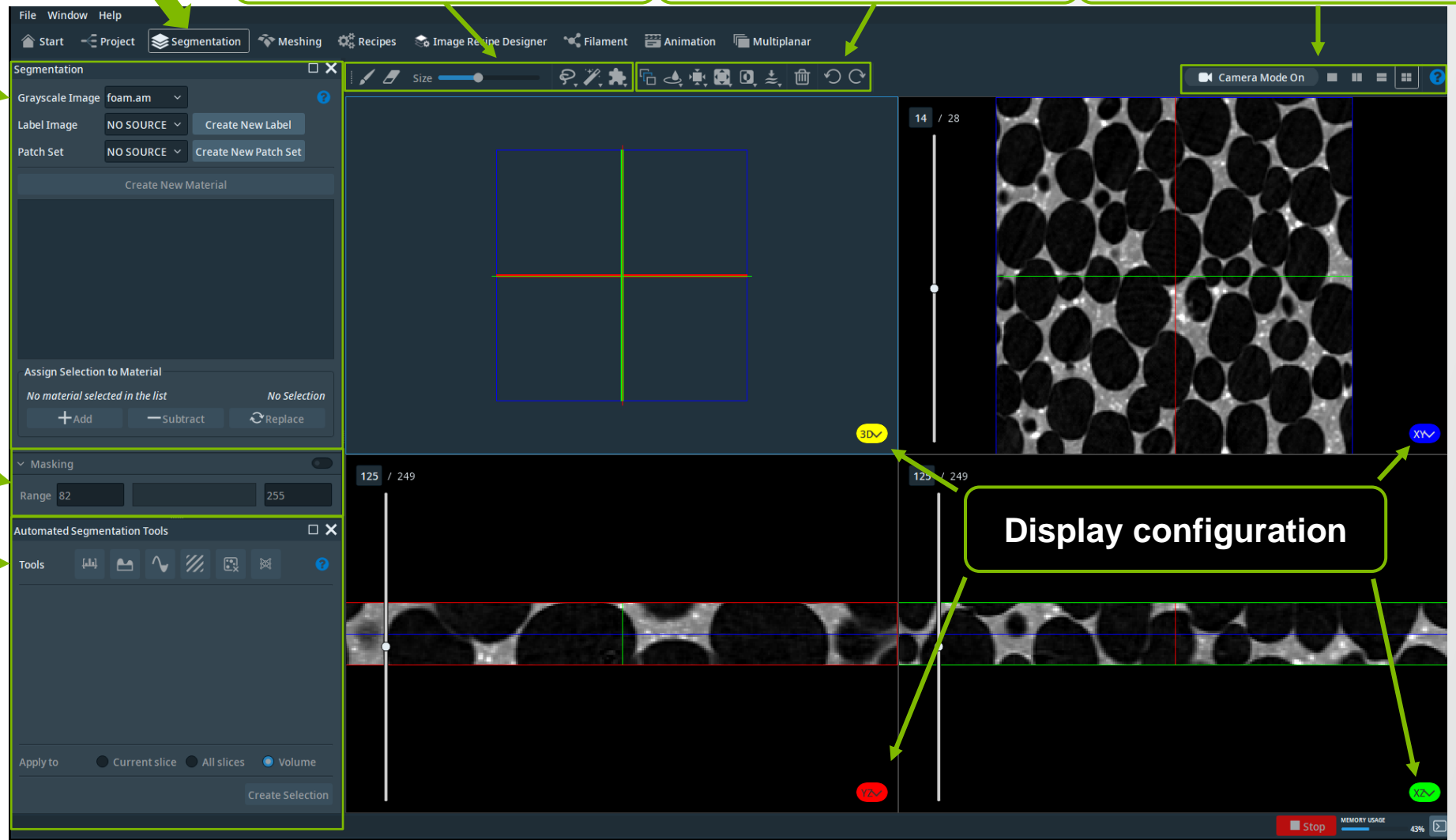
Select viewer mode

Segmentation panel

Masking tool

Automated tools for generating selections

Display configuration



Segmentation Editor: workroom

Dedicated workroom for interactive segmentation

The image shows the Segmentation Editor workroom interface with several callouts and a dialog box. The interface includes a menu bar (File, Window, Help), a toolbar (Start, Project, Segmentation, Meshing), and a main workspace. The workspace is divided into several sections: a top section for field creation, a middle section for material management, and a bottom section for patch set navigation.

Callouts and their corresponding interface elements:

- Image Field** (green box) points to the "foam.am" dropdown in the "Grayscale Image" section.
- Create Label Field** (orange box) points to the "Create New Label" button in the "Label Image" section.
- Create Patch Set** (purple box) points to the "Create New Patch Set" button in the "Patch Set" section.
- Selection manipulation** (green box) points to the "Assign Selection to Material" section, which includes "No material selected in the list", "No Selection", and buttons for "+Add", "-Subtract", and "Replace".
- Patch Set Navigation** (green box) points to the "Patch Set Navigation" section, which includes a "Patches" slider and a "0 / 0" indicator.

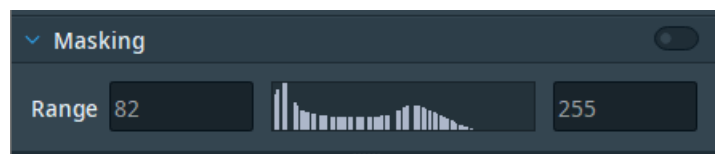
A dialog box titled "Dialog" is shown on the right, with the text "Choose the size of patches" and "The size of patches are multiple of 32". It features a dropdown menu with the value "64" and an "OK" button.

Segmentation Editor: general principle

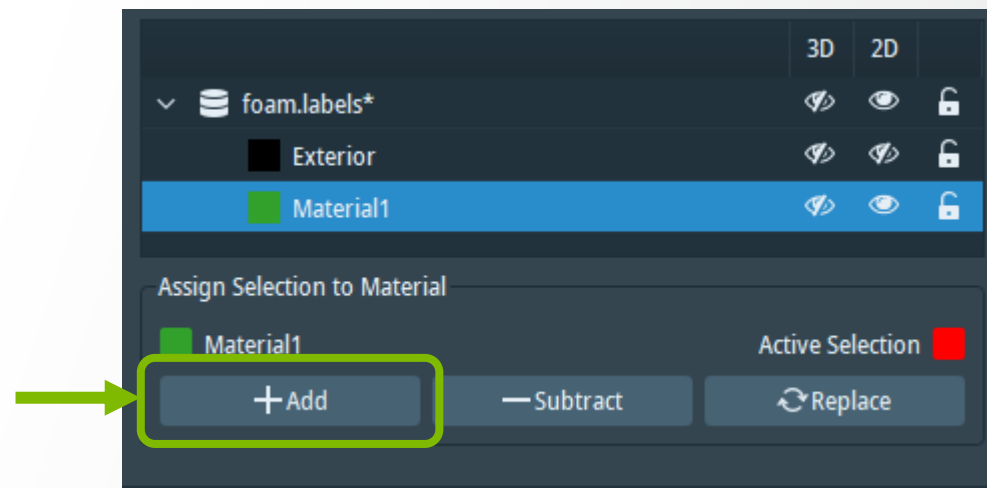
- **Generate selection** using the tools available in the selection generation toolbar e.g. Brush, Lasso, Magic Wand (region growing), Superpixel
- **Assign selection** to material using the tools available in the selection assignment toolbar



- Apply **masking** to assist the segmentation with the brush tool and magic wand.

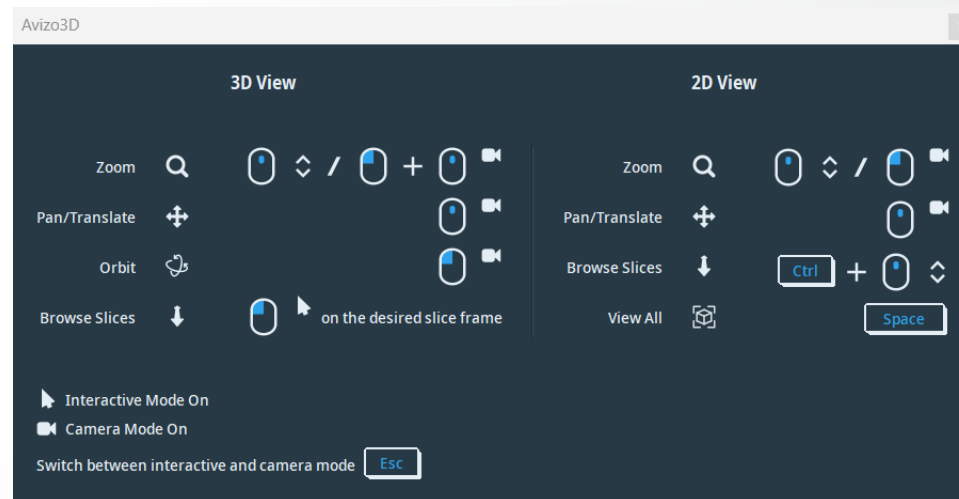
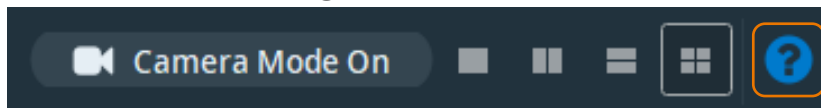


- **Modify selection** using the tools available in the selection modification toolbar

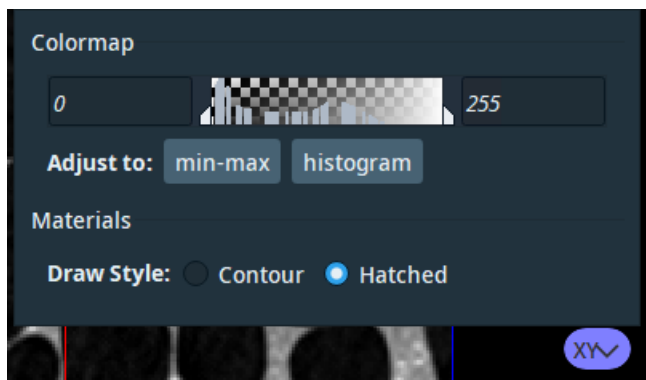


Segmentation Editor: Image Viewers and Navigators

- Switch between the 1, 2 or 4 **viewer modes** in the Viewer toolbar. A summary of navigation shortcuts is available through the Help button, at the right of the Viewer toolbar.



- Adjust the display configuration** in the display menu at the bottom right part of each viewer



Segmentation Editor: Selection generation tools



Brush: 2D painting

- Right click inside close contour: flood fill in 2D
- CTRL: erase



Eraser: 2D removing

- Successive paint strokes remove voxels from the selection.



Brush size

- Adjusts the size of both the **brush** and **eraser tools**



Lasso: 2D & 3D closed contours

- Generate selections in 2D and 3D by defining closed contours
- “Auto-trace” option: snap to gradient (in 2D)



Magic Wand: 2D & 3D

- Region growing within intensity range selected with the mask

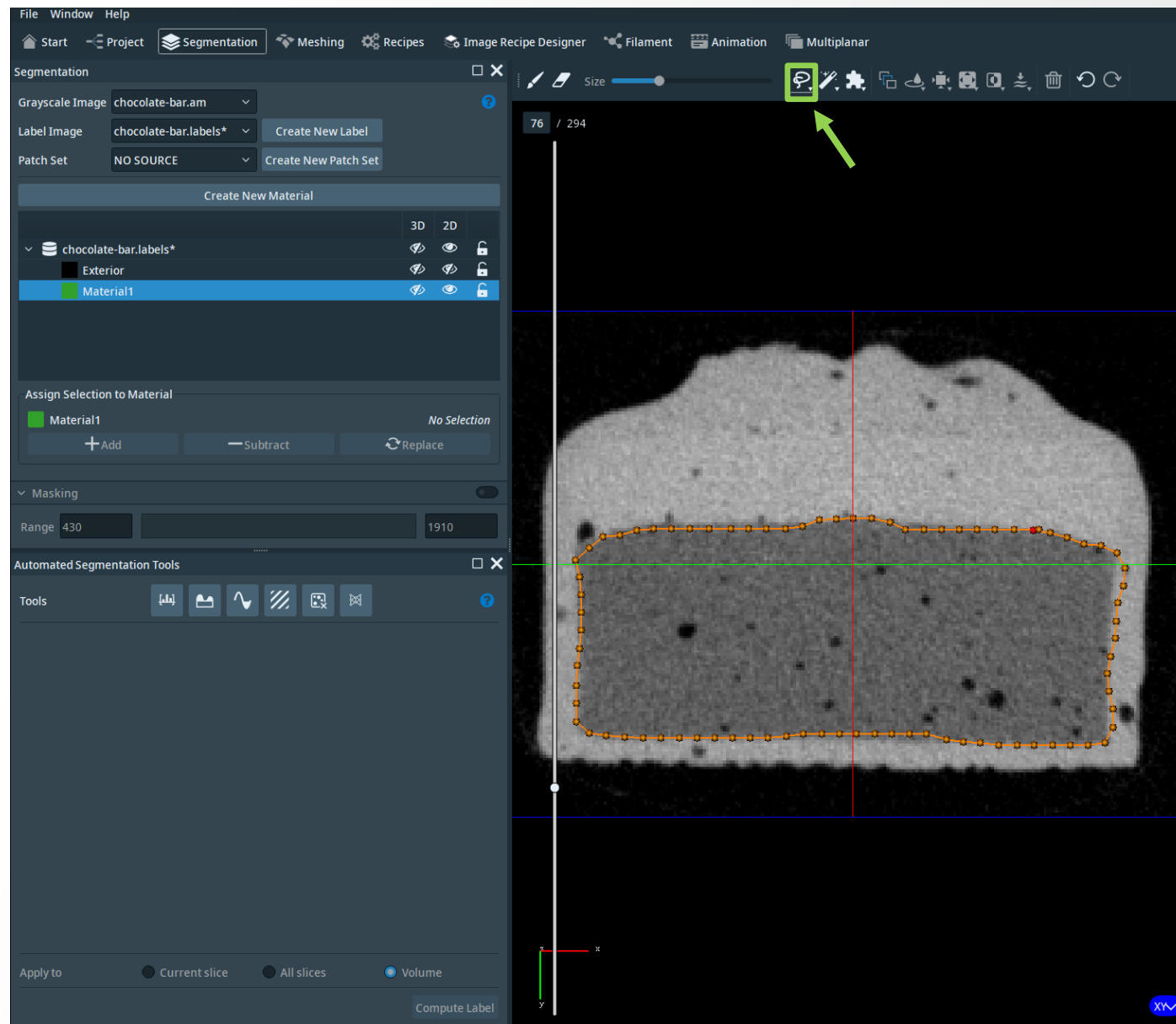


Superpixel: 2D

- Partitions the image into superpixels that share common characteristics.
- Brush the partitions to add them to the selection
- CTRL: erase

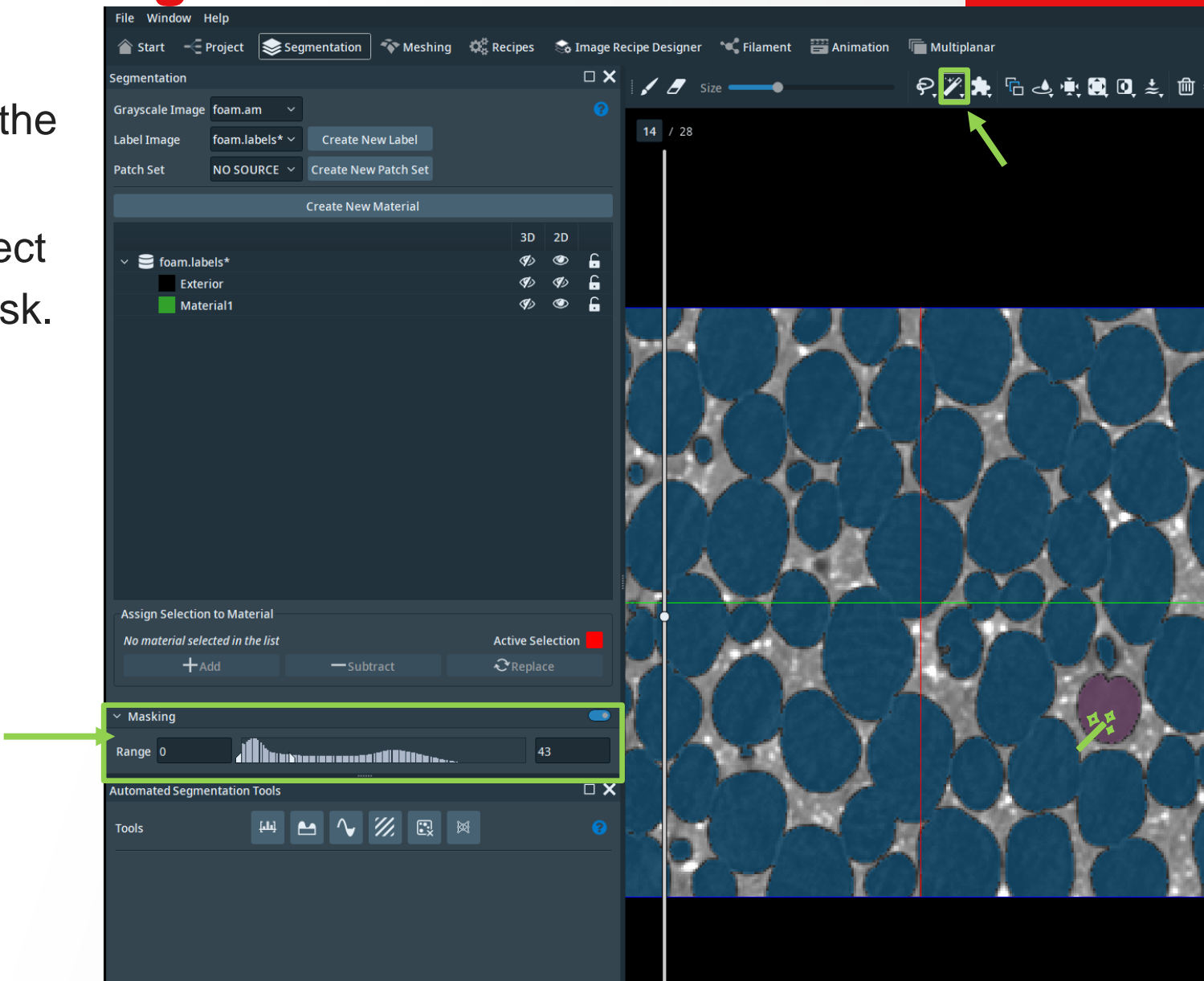
Selection generation tools: Lasso

- Draw the border of a polygonal area with the lasso tool.
- Hold left mouse button for automatically created control points
- Or click at each point individually
- Press ENTER once to edit the control points
- Press ENTER again to finalize the selection



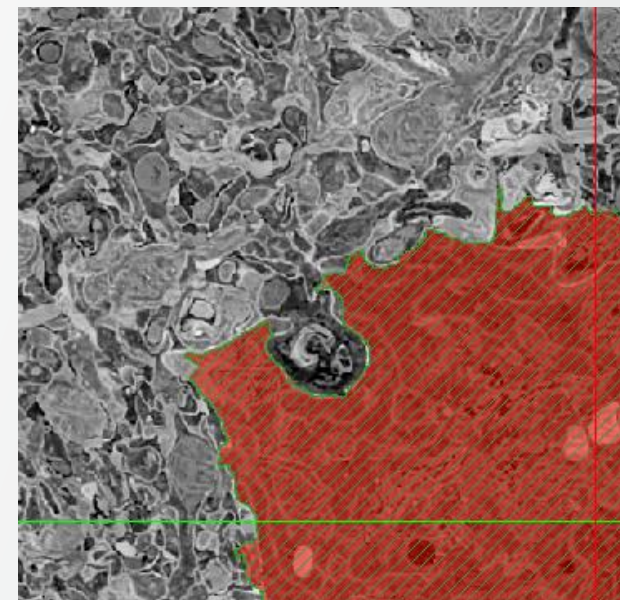
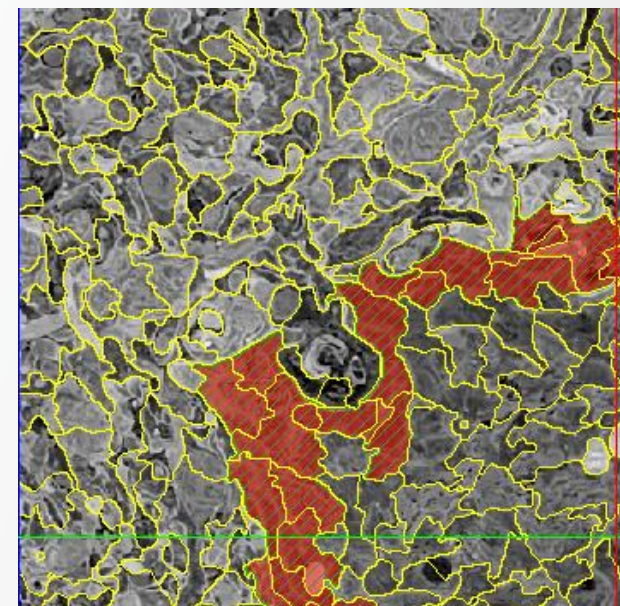
Selection generation tools: Magic Wand

- Adjust the intensity range to mask the feature of interest.
- Click on a blue shaded area to select the connected pixels within the mask.



Selection generation tools: Superpixel

- **Superpixel (S)**: partitions the image displayed in the currently active 2D viewers into superpixels. The pixel follow the edges of the image.
- Tool parameters, colormap range, camera position and zoom level affect the size and shape of the partitions.
- Brush in the viewer to add superpixels to the voxel selection.



Segmentation Editor: Selection modification tools



Interpolate: between selections from parallel slices

- Shape-based interpolation



Fill holes (2D or 3D)



Shrink (2D or 3D)



Grow (2D or 3D)



Invert Selection



Smooth (2D only)



Clear selection



Undo



Redo



Create patches

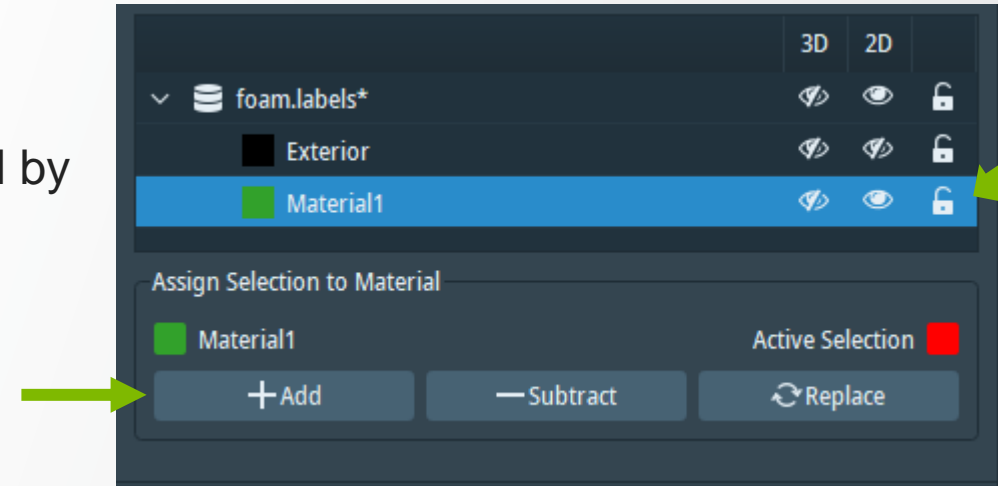
Segmentation Editor: materials assignment

Materials assignment:

- Add selection to material (or replace / subtract)
- Materials can be locked to disable any changes to the Material by clicking the lock button.

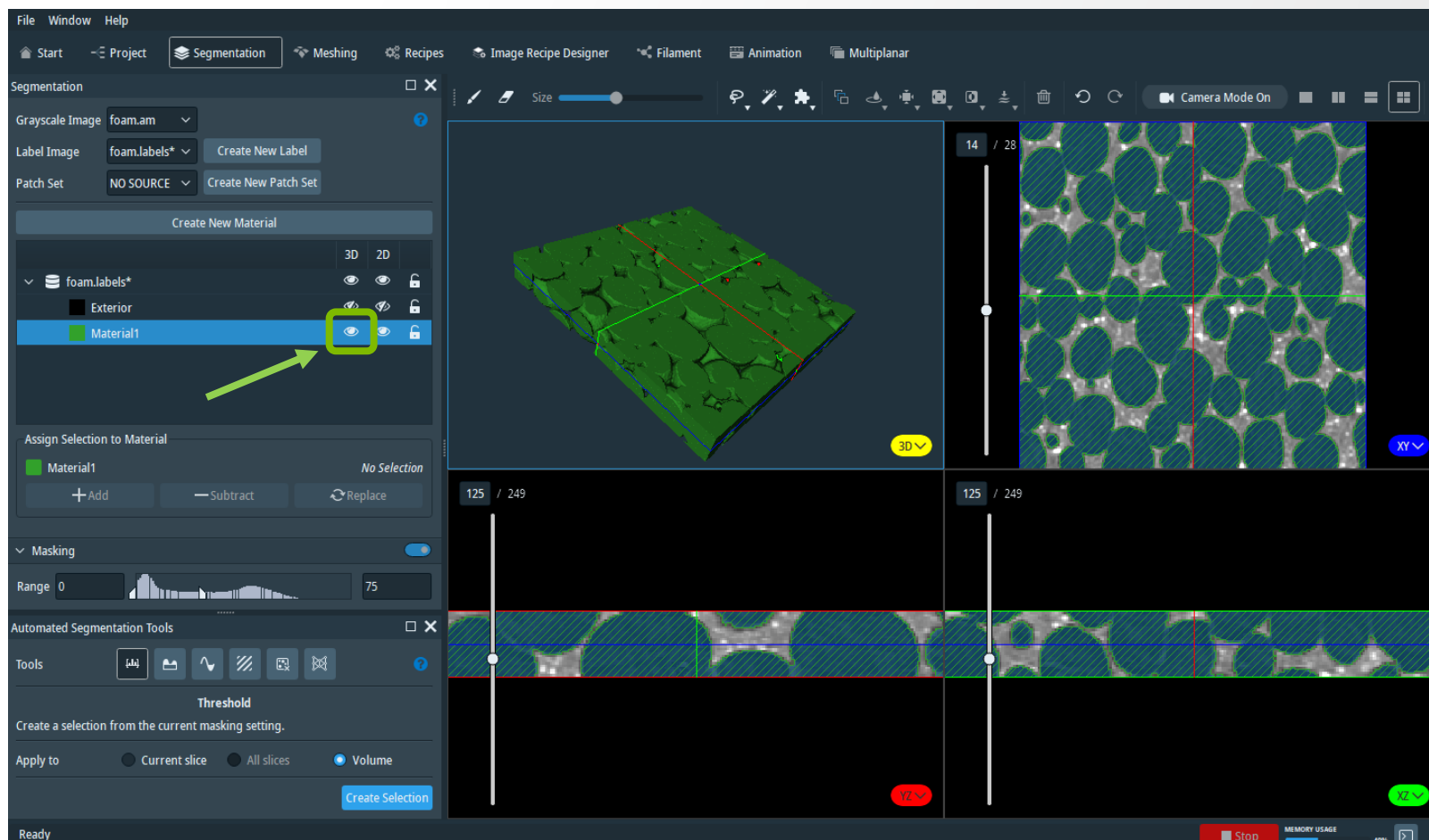
Rules of thumb:

- Only one label per voxel
- Always keep the “Exterior” material



Segmentation Editor: materials visualization

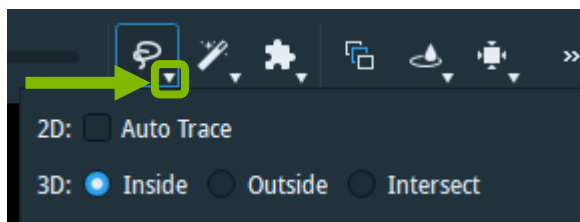
- Click on the eye button to activate the visualization of the material in the 3D viewer



Segmentation Editor: Selection tools

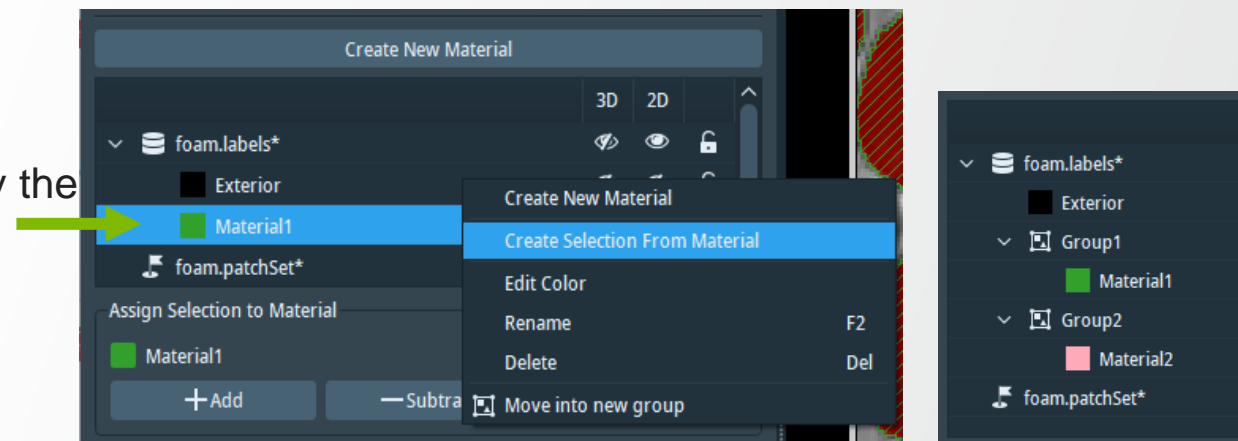
- **Tips:**

- Click the downward arrow on the selection tool for more options



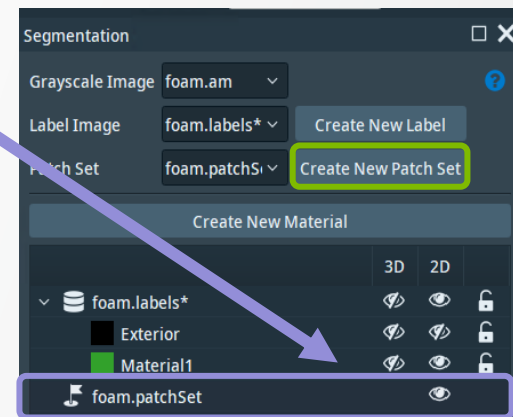
- Right-click a material to:

- Create a new material
- Select the complete material, when you want to modify the
- Edit display color
- Rename the material
- Delete the material
- Create a new group to move the material into



Segmentation Editor: Patch tool

- The Patch tool is relevant for using AI Assisted Segmentation
- When a new patch set is created, it appears in the material list.

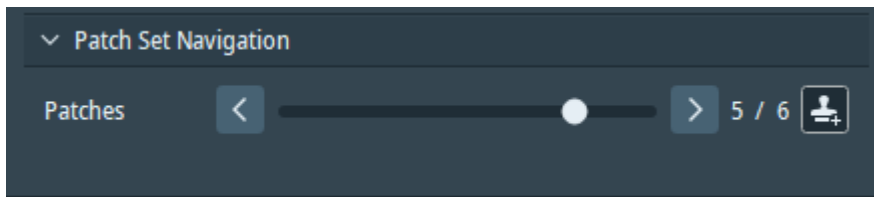


- Use the Add patches tool to stamp patches on the XY image.



Add patches tool

- Navigate through the patch set to select individual patches. Press Delete to remove them one at a time.



Segmentation Editor: Automated selection tools



Threshold

- Select the image intensity range in the “Masking” window
- > Create a selection for the current slice or total volume
- > Add the selection to a material



Top-hat

- Compute a top-hat image to detect dark or bright features
- Select a threshold for the feature



Watershed

- Grow regions from seed points.
- Edge detection based on a computed gradient image



Texture classification

- Label regions with different textures. The classifier learns to recognize the features for the whole image.



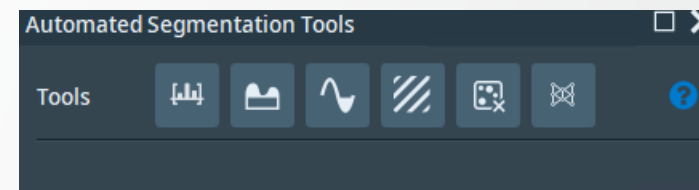
Remove islands

- Merge small islands with the surrounding material.



AI Assisted segmentation

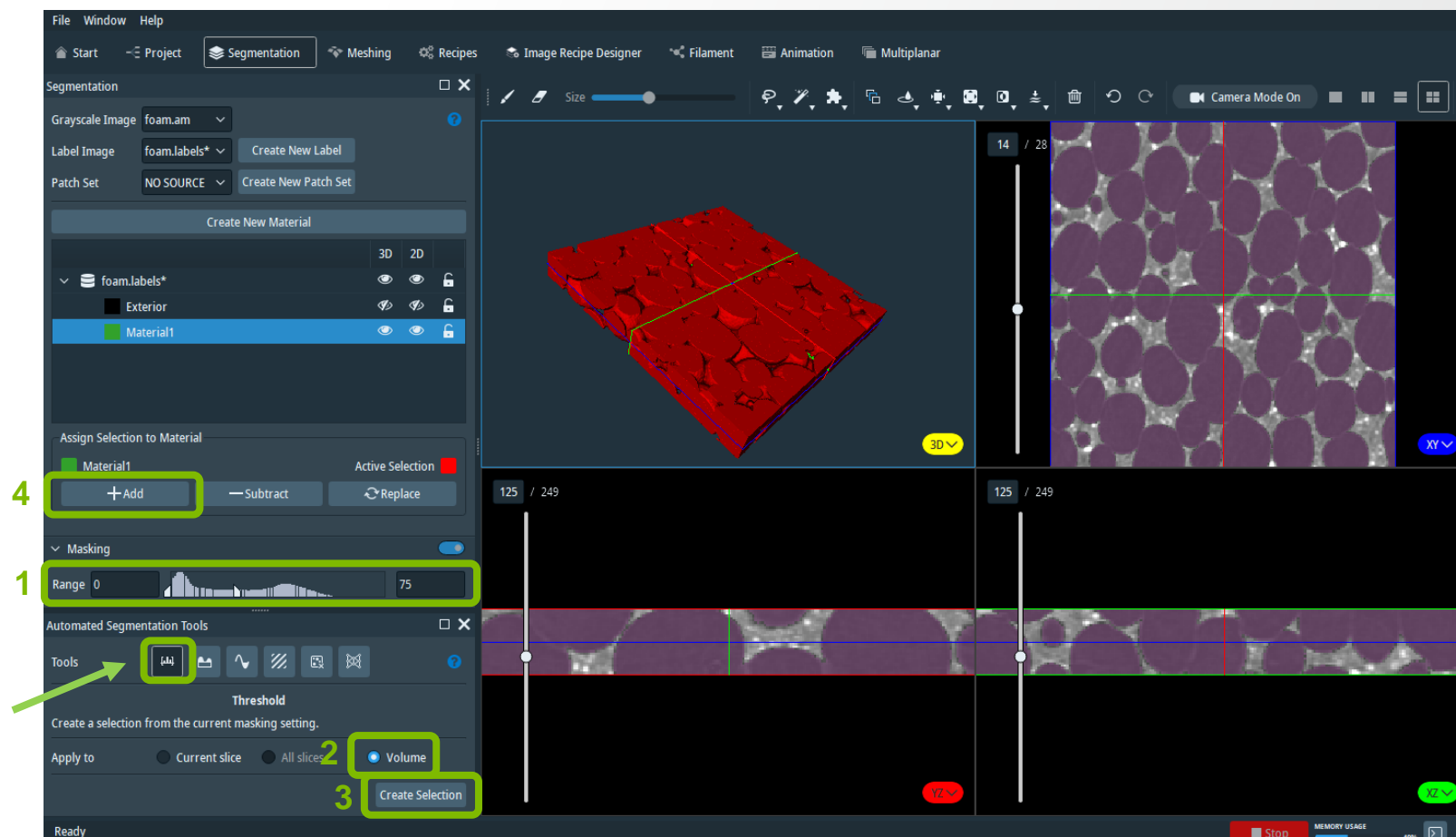
- Train and apply a shallow neural network on patches containing ground truth.



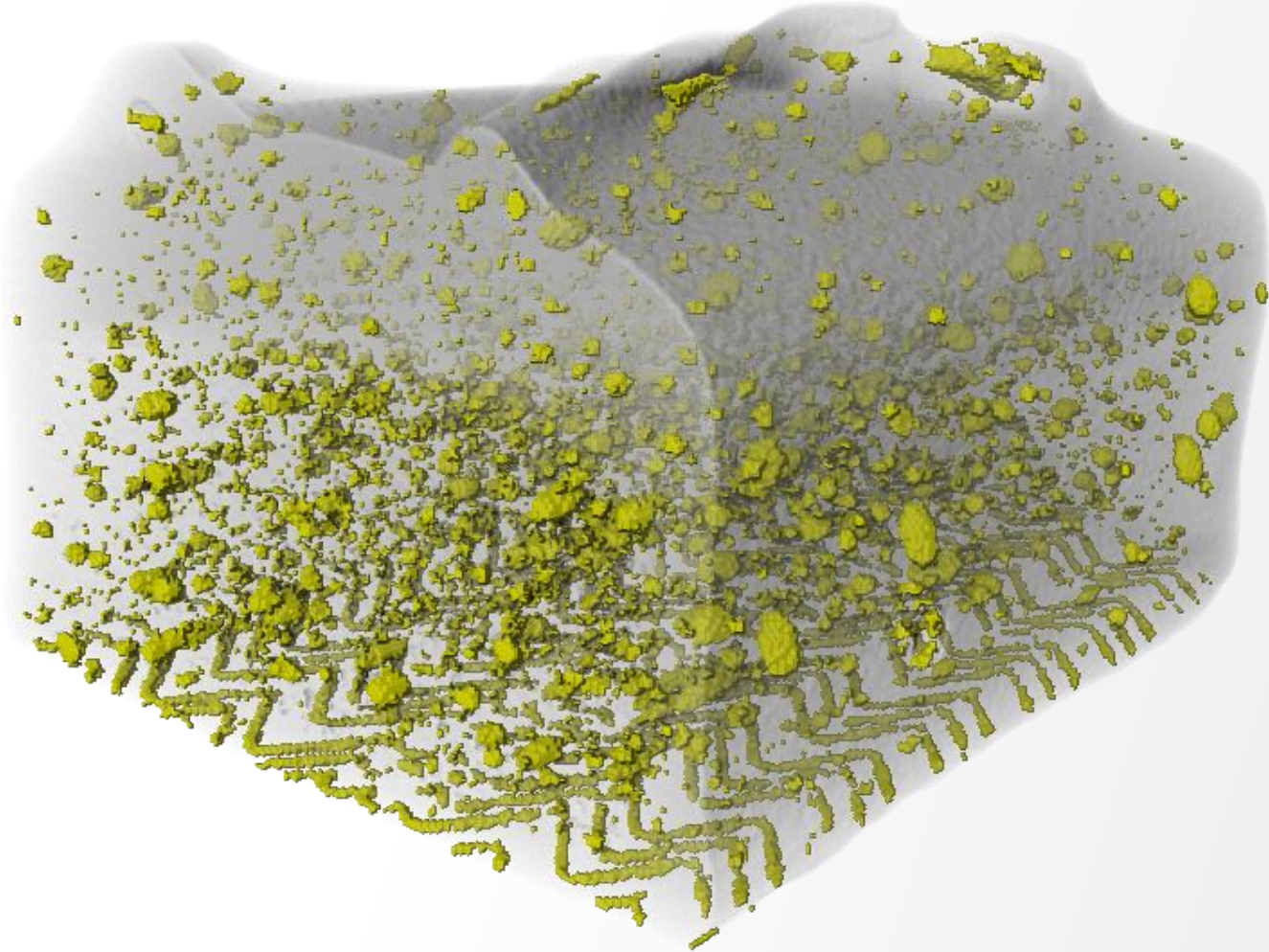
Automated Segmentation Tools: Threshold

Segment the pores in *foam.am* using the Automated Thresholding tool

- 1. Set the desired intensity range in the Masking window
- 2. Select if you want to apply it on the current slice only or the full volume
- 3. Click **Create Selection**
- 4. **Add** the selection to the material



Automated Segmentation Tools: Top-Hat



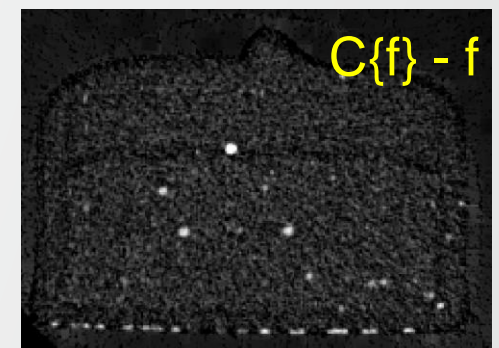
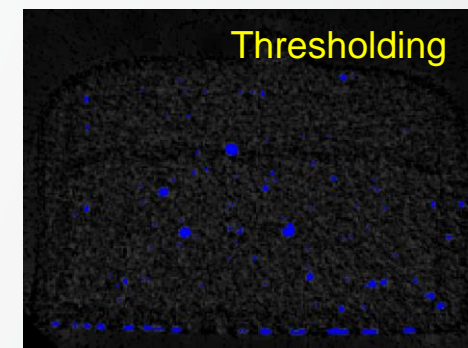
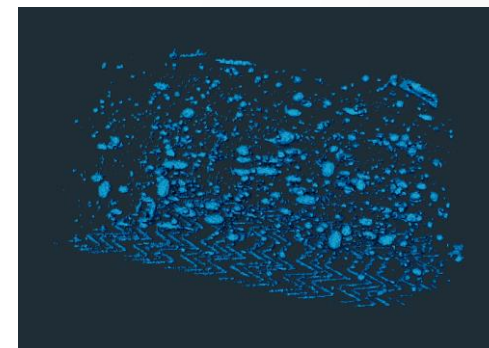
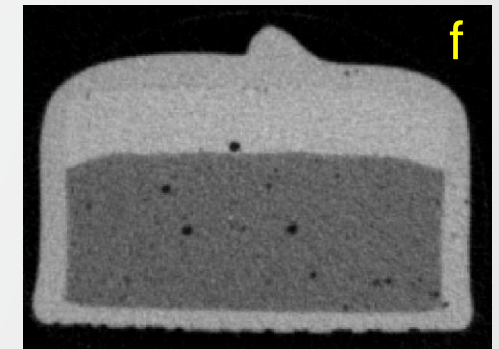
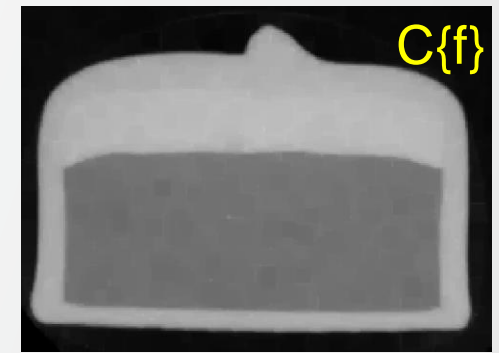
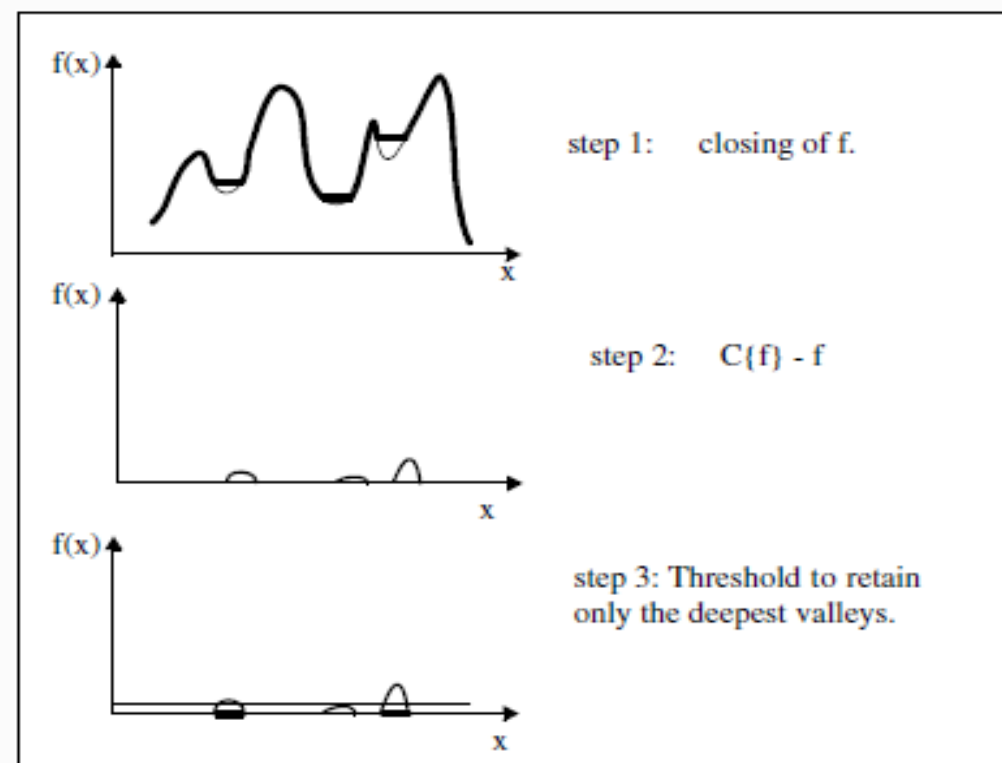
Automated Segmentation Tools: Top-Hat

The Top-Hat segmentation extracts small elements and details from given images. It detects the dark or the white area, corresponding to the valleys or the narrow peaks.

Top-Hat computation perform (1) Grayscale Closing ($C\{f\}$) of Original Grayscale followed by (2) Subtract Grayscale Closing by Original Grayscale ($C\{f\} - f$) to yield a Top-Hat image and (3) Thresholding of the Top-Hat image

There exist two types of Top-Hat transform:

- The Black Top-Hat: it is defined as the difference between the cube closing with a given size kernel and the input image. A threshold allows selecting the darker elements of the Top-Hat result.
- The White Top-Hat: it is defined as the difference between the input image and its opening cube. The threshold allows selecting the brighter elements of the Top-Hat result.



Automated Segmentation Tools: Top-Hat

The screenshot displays the Avizo 3D software interface. The 'Segmentation' tab is active, and the 'Automated Segmentation Tools' panel is open, showing the 'Top-hat' tool configuration. The 'Grayscale Image' is set to 'chocolate-bar.am' and the 'Label Image' is 'chocolate-bar.labels*'. The 'Top-hat' tool settings include 'Type' set to 'Black', 'Kernel' set to 'Ball', and 'Size' set to '3px'. The 'Compute Top-hat Image' button is highlighted with a red arrow. The 3D visualization shows a chocolate bar with a dark interior and a lighter, textured exterior, segmented into two regions. The 'Avizo' logo is visible in the bottom left corner, and the 'Stop' button and 'MEMORY USAGE' indicator are in the bottom right corner.

Automated Segmentation Tools: Top-Hat

The screenshot displays the Avizo 3D software interface with the Segmentation panel on the left and a 3D visualization of a chocolate bar cross-section on the right. The Segmentation panel includes the following sections:

- Grayscale Image:** chocolate-bar.am
- Label Image:** chocolate-bar.labels* (with a "Create New Label" button)
- Patch Set:** NO SOURCE (with a "Create New Patch Set" button)
- Create New Material:** A section for creating new materials.
- Material List:** A list containing "chocolate-bar.labels*" with a sub-entry "Exterior".
- Assign Selection to Material:** A section with "No material selected in the list" and "No Selection" buttons, and "Add", "Subtract", and "Replace" buttons.
- Masking:** A section with a "Range" slider set from 410 to 1910.
- Automated Segmentation Tools:** A section with various tool icons.
- Top-hat:** A section with an information icon and the text "2/2: Use the Top-hat Range to change black areas depth". It includes:
 - Type:** Radio buttons for "Black" (selected) and "White".
 - Kernel:** A dropdown menu set to "Ball" and a "Size" field set to "3px".
 - Options:** Radio buttons for "Faster" and "Precise" (selected).
 - Buttons:** "Recompute Top-hat Image".
- Selection Settings:** A section with a "Filter" checkbox (checked) and a dropdown menu set to "Exterior".
- Top-hat Range:** A slider set from 351 to 123.
- Apply to:** Radio buttons for "Current slice", "All slices", and "Volume" (selected).
- Buttons:** "Create Selection" (highlighted with a red box).

The 3D visualization on the right shows a grayscale image of a chocolate bar cross-section. A blue bounding box is drawn around the bar. A green arrow points from the "Top-hat Range" slider to the bar, and another green arrow points from the "Create Selection" button to the bar. The bottom status bar shows "Avizo™", "Camera Mode On", "Stop", "MEMORY USAGE", and "12%".

Automated Segmentation Tools: Top-Hat

The screenshot displays the Avizo 3D software interface. On the left, the Segmentation panel is active, showing the following settings:

- Grayscale Image: chocolate-bar.am
- Label Image: chocolate-bar.labels* (with a 'Create New Label' button)
- Patch Set: NO SOURCE (with a 'Create New Patch Set' button)
- Material List: Material1 (highlighted in blue)
- Assign Selection to Material: Material1 (with an '+ Add' button highlighted in green)
- Masking: Range 410
- Automated Segmentation Tools: Top-hat tool selected (highlighted in green)
- Top-hat Tool Settings:
 - Type: Black (selected)
 - Kernel: Ball
 - Size: 3px
 - Options: Faster, Precise (selected)
 - Recompute Top-hat Image button
 - Selection Settings: Filter 'Select only in material' (unchecked), Exterior (selected)
 - Top-hat Range: 351 to 1239
 - Apply to: Current slice, All slices, Volume (selected)
 - Create Selection button

On the right, a 3D visualization shows a grayscale cross-section of a chocolate bar. The top layer is light gray, and the bottom layer is dark gray. A blue bounding box is drawn around the bar. A vertical white line is positioned at the center of the bar. A green arrow points from the 'Top-hat' tool icon to the dark gray area of the bar. Another green arrow points from the '+ Add' button to the 'Material1' entry in the material list. The bottom status bar shows 'Avizo™', 'MEMORY USAGE 13%', and a 'Stop' button.

Automated Segmentation Tools: Top-Hat

The screenshot displays the Avizo 3D software interface, specifically the Segmentation module. The main window shows a 3D visualization of a chocolate bar cross-section, with a dark central region and a lighter outer region. A green arrow points from the 'Top-hat' tool settings in the left panel to the dark central region of the chocolate bar in the 3D view.

Segmentation Panel:

- Grayscale Image: chocolate-bar.am
- Label Image: chocolate-bar.labels* (Create New Label)
- Patch Set: NO SOURCE (Create New Patch Set)
- Create New Material: Material1 (3D, 2D, eye, lock icons)
- Assign Selection to Material: Material1 (No Selection, Add, Subtract, Replace buttons)

Masking Panel:

- Range: 410 - 1910
- Automated Segmentation Tools: Top-hat
- Tools: [Icons for various segmentation tools]
- Top-hat: 2/2: Use the Top-hat Range to change black areas depth
- Type: Black (selected), White
- Kernel: Ball, Size: 3px
- Options: Faster, Precise (selected)
- Recompute Top-hat Image button

Selection Settings Panel:

- Filter: Select only in material (checked), Exterior (dropdown)
- Top-hat Range: 351 - 1239
- Apply to: Current slice, All slices, Volume (selected)
- Create Selection button

3D View:

- 147 / 294 (slice indicator)
- Camera Mode On (toggle)
- Avizo logo and system status (Stop, MEMORY USAGE 12%)

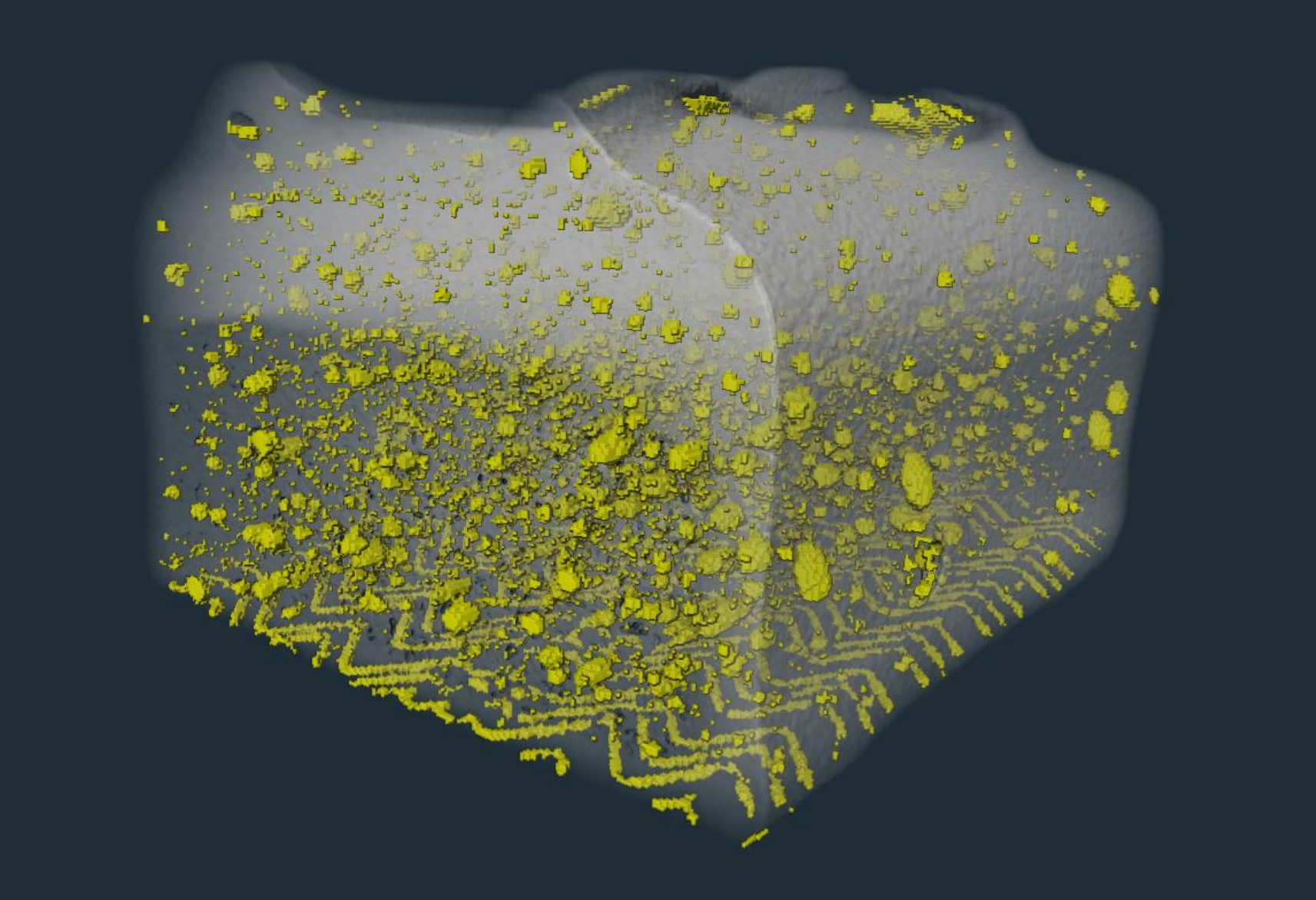
Automated Segmentation Tools: Top-Hat

The screenshot displays the Avizo 3D software interface, specifically the Segmentation module. The main window shows a 3D visualization of a chocolate bar with a yellow material selection. The interface includes a menu bar (File, Window, Help) and a toolbar with various segmentation tools. The Segmentation panel on the left shows the following settings:

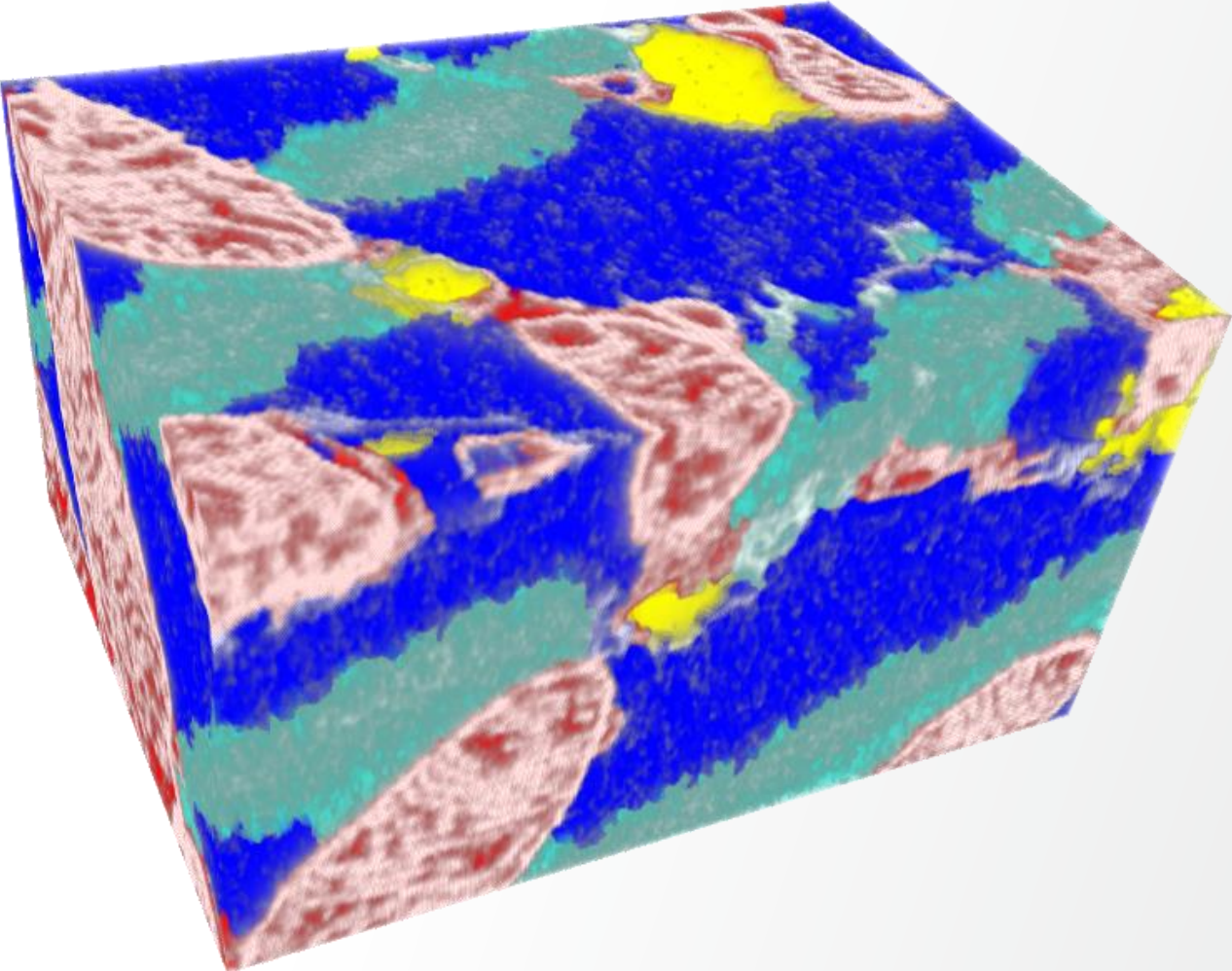
- Grayscale Image: chocolate-bar.am
- Label Image: chocolate-bar.labels* (with a "Create New Label" button)
- Patch Set: NO SOURCE (with a "Create New Patch Set" button)
- Create New Material section with "Material1" selected.
- Assign Selection to Material section with "Material1" and "No Selection" options.
- Masking section with Range 410 to 1910.
- Automated Segmentation Tools section with the Top-hat tool selected.
- Top-hat tool settings: Type: Black, Kernel: Ball, Size: 3px, Precise mode selected.
- Selection Settings: Filter: Select only in material, Exterior selected.
- Top-hat Range: 351 to 1239.
- Apply to: Volume selected.

The 3D visualization shows a chocolate bar with a yellow material selection. The interface also includes a 2D slice view on the right, showing a grayscale image of the chocolate bar with a yellow selection. The bottom status bar shows "Avizo™", "3D" mode, "MEMORY USAGE 13%", and a "Stop" button.

Automated Segmentation Tools: Top-Hat



Automated Segmentation Tools: Texture Classification



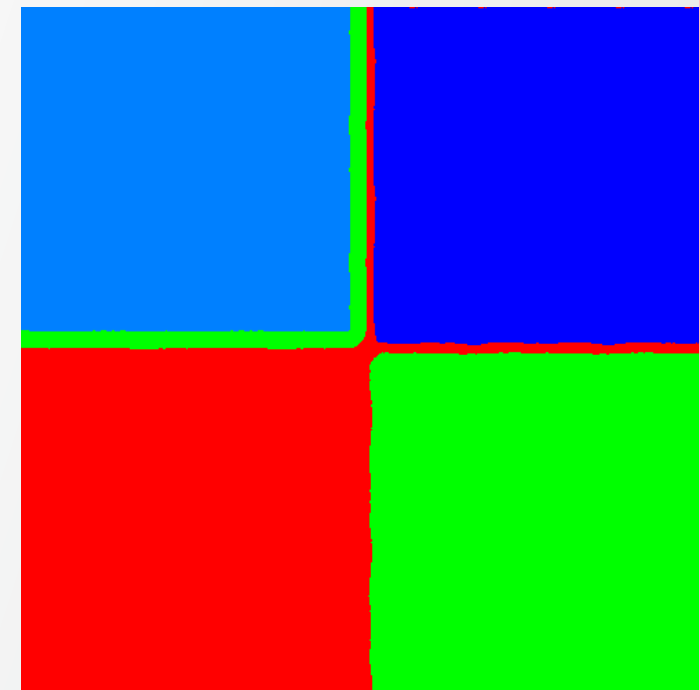
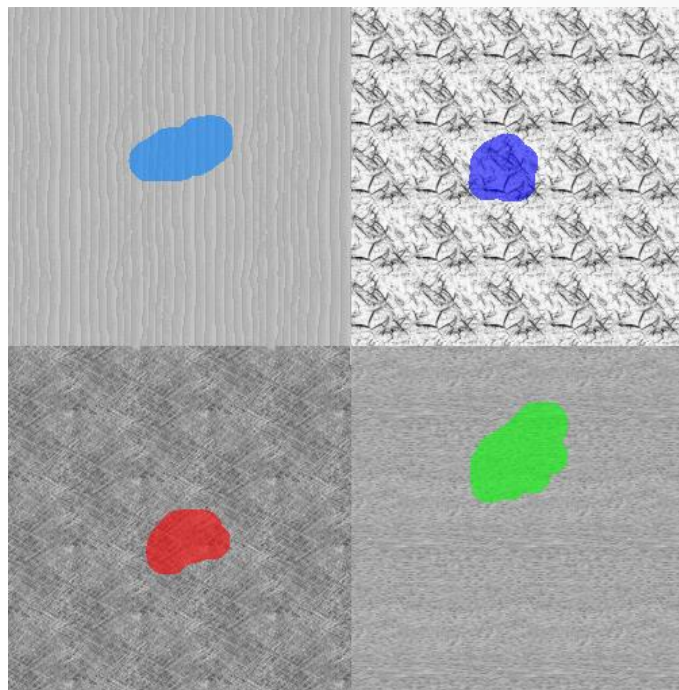
Automated Segmentation Tools: Texture Classification

Texture supervised classification aims at performing image segmentation based on local textural features, when typical intensity-based methods are not appropriate.

A texture classification workflow is composed of 3 main steps:

- Selection of texture features considered in the model
- Learning of a texture model on representative annotated training data
- Application of the texture model to segment a new image

During the learning step, all the selected features are computed on a local neighborhood of pixels belonging to labels defined in a training image. A subset of discriminant features is retained and only these features are computed during the segmentation step.



Automated Segmentation Tools: Texture Classification

The screenshot displays the Amira 3D software interface with the Segmentation module active. The main window shows a grayscale image of a biological sample, likely a heart section, with various structures highlighted in different colors. The interface includes a menu bar (File, Window, Help), a toolbar with various tools, and a central workspace showing the image. The Segmentation panel on the left contains the following elements:

- Grayscale Image:** DBI_heart_view.am
- Label Image:** DBI_heart_view.labels*
- Patch Set:** NO SOURCE
- Create New Material:** A button highlighted with a green box.
- Material List:** A list of materials with checkboxes for 3D and 2D views and lock icons. The materials are: Exterior, Contractile_Filaments, Mitochondria, Heart_Tissue, and T-Tubule. Green arrows point to the checkboxes for Contractile_Filaments, Mitochondria, Heart_Tissue, and T-Tubule.
- Assign Selection to Material:** A section with buttons for Add, Subtract, and Replace.
- Masking:** A section with a Range slider set from 165 to 255.
- Automated Segmentation Tools:** A section with icons for various tools and an Apply to dropdown menu set to Volume.

The bottom status bar shows "Ready" and "MEMORY USAGE 24%".

Automated Segmentation Tools: Texture Classification

The screenshot displays the Amira 3D software interface, specifically the 'Automated Segmentation Tools' window. The 'Texture Classification' section is active, showing the following settings:

- Feature Type:** Rotation invariant cooccurrence, First order statistics, Directional cooccurrence, Histogram statistics
- Radius:** 25px
- Texon:** Shape: Cube, Size: 2px
- Feature Rejection:** 5.0%
- Uncertainty Threshold:** 3.0
- 2D preview:** Compute Preview, Auto compute (disabled)
- Output Label:** Overwrite, New, DBI_heart_view.labels*
- Apply to:** Current slice, All slices, Volume

The 'Segmentation' panel on the left shows the material list for 'DBI_heart_view.labels*':

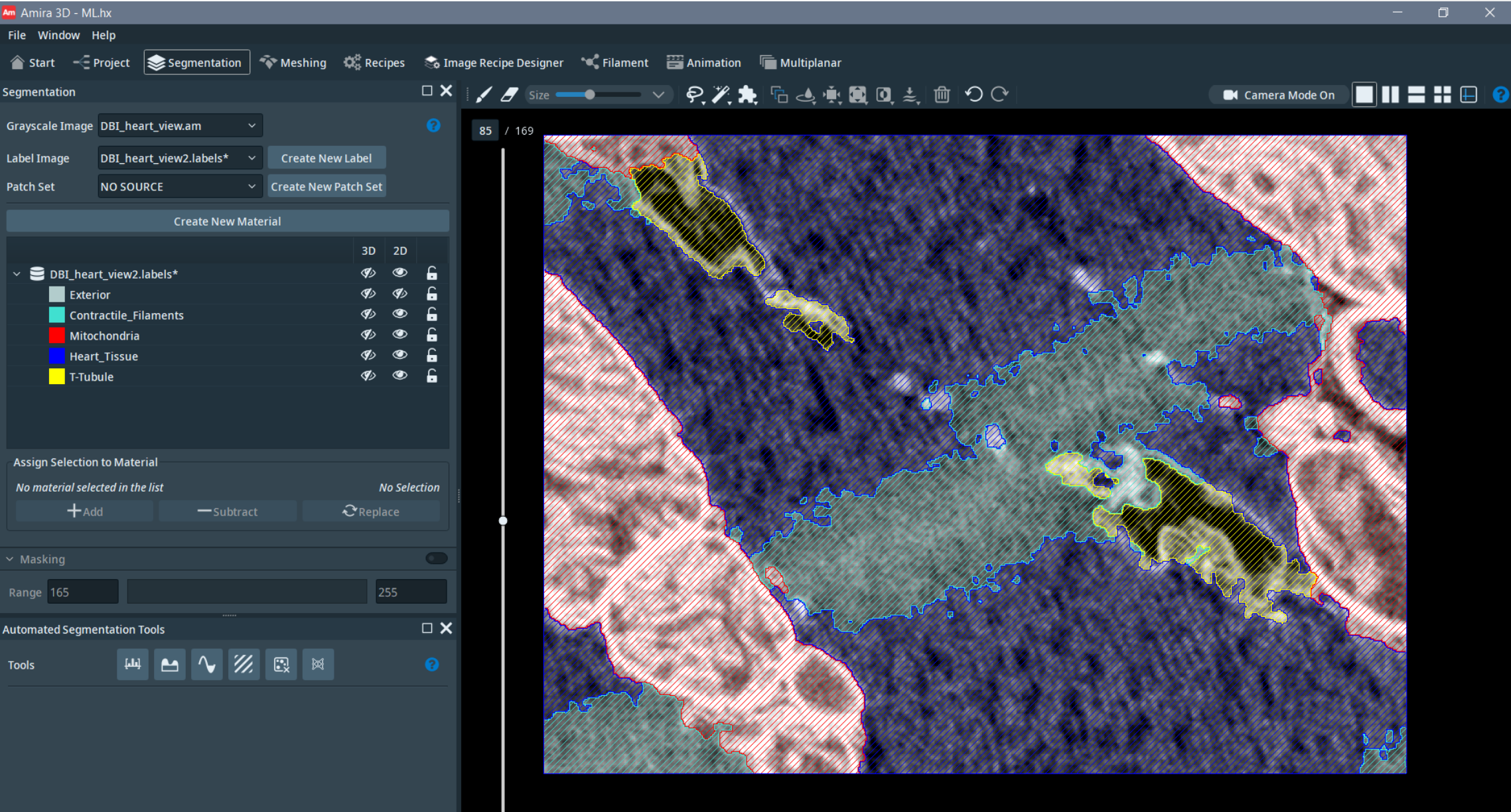
- Exterior (grey)
- Contractile_Filaments (cyan)
- Mitochondria (red)
- Heart_Tissue (blue)
- T-Tubule (yellow)

Arrows indicate the mapping from these materials to the corresponding segments in the 3D view: Contractile_Filaments to cyan, Mitochondria to red, Heart_Tissue to blue, and T-Tubule to yellow. The 3D view shows a grayscale image of a heart slice with these segments highlighted and textured. The 'Amira' logo is visible in the bottom left corner, and the 'MEMORY USAGE' indicator shows 24% usage in the bottom right corner.

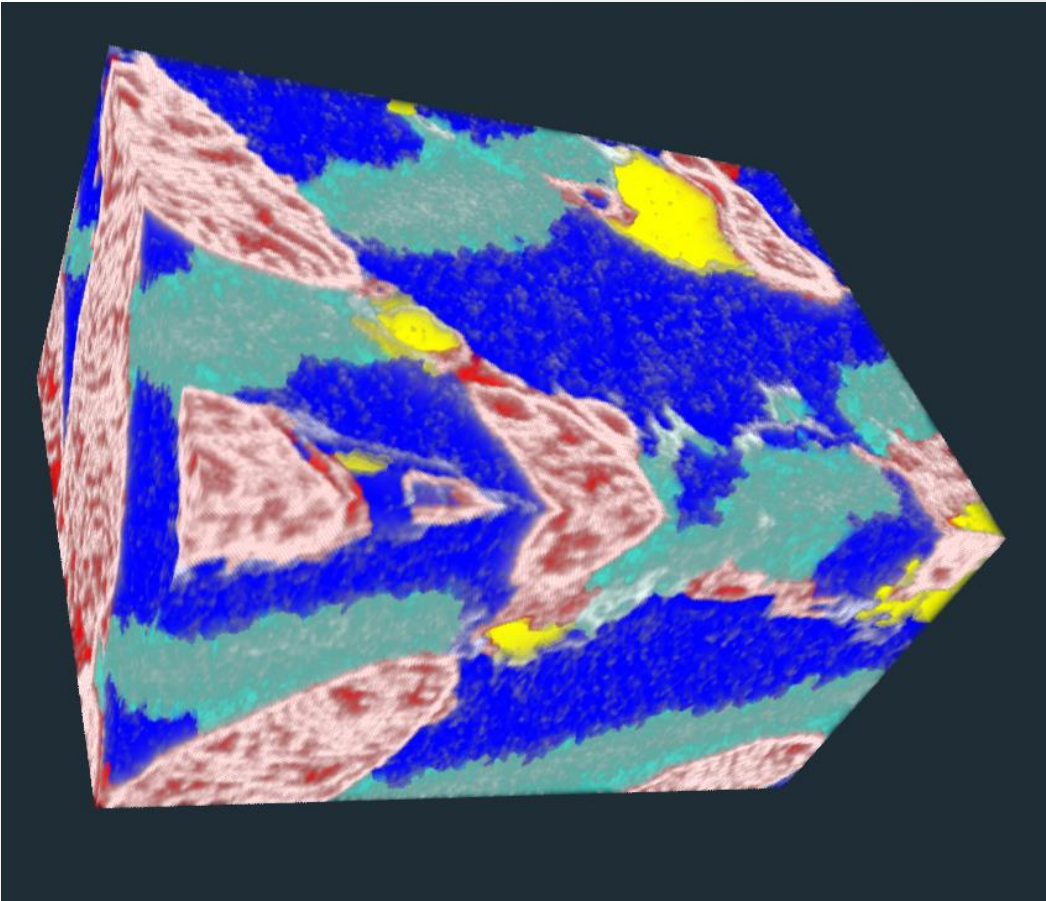
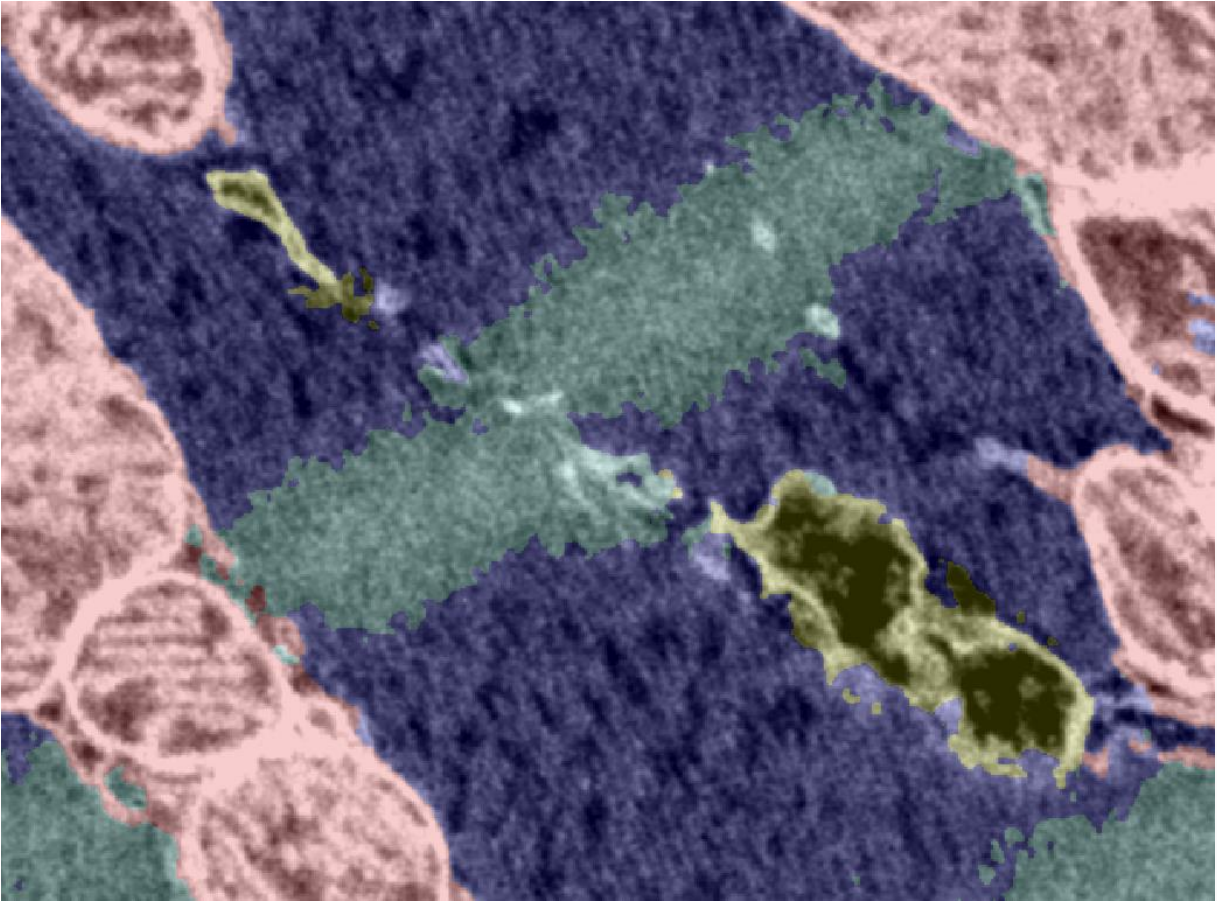
Automated Segmentation Tools: Texture Classification

The screenshot displays the Amira 3D software interface for automated segmentation. The main window shows a 3D volume with segmented regions in red, blue, green, and yellow, each with a unique texture. The 'Segmentation' panel on the left lists materials: Exterior (gray), Contractile_Filaments (cyan), Mitochondria (red), Heart_Tissue (blue), and T-Tubule (yellow). The 'Automated Segmentation Tools' panel is open, showing the 'Texture Classification' tool. The tool settings include: Feature Type (First order statistics and Histogram statistics checked), Radius (25px), Texton (Cube, 2px), Feature Rejection (5.0%), and Uncertainty Threshold (3.0). The 'Compute Preview' button is highlighted with a green box, and the 'Compute Label' button is highlighted with a blue box. A green arrow points from the 'Compute Label' button to the 3D view. The 3D view shows the segmented volume with the corresponding textures and colors. The 'Amira' logo is visible in the bottom left corner of the 3D view.

Automated Segmentation Tools: Texture Classification



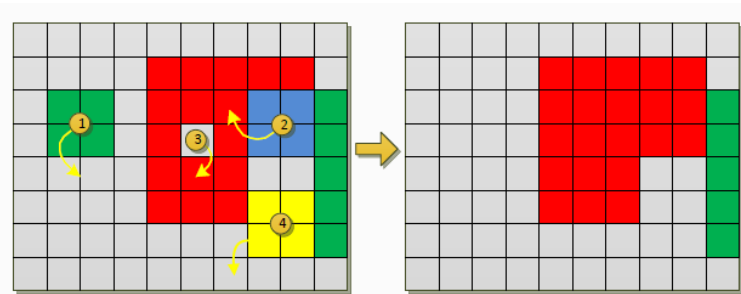
Automated Segmentation Tools: Texture Classification



Automated Segmentation Tools: Remove Islands

Merge small areas to the surrounding material.

- Define the island max size.
- Click **Compute highlight** to get a preview of which islands will be removed.
- Select if you want to overwrite the current label or create a new label.
- Click **Compute Label** to apply the action.

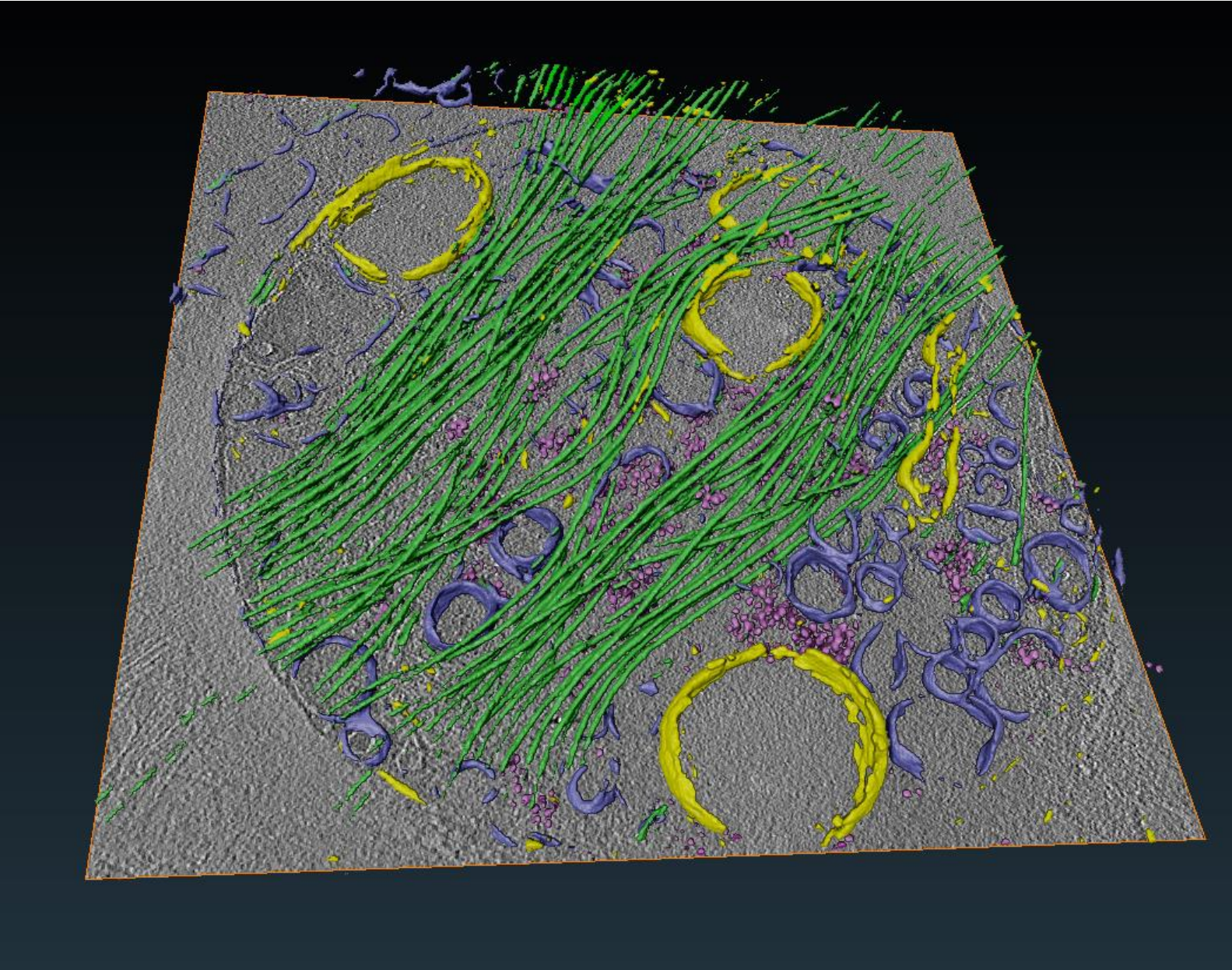


The screenshot displays the software's 'Segmentation' and 'Automated Segmentation Tools' panels. The 'Remove Islands' tool is active, with the following settings:

- Island max size:** 60px
- Highlight islands:** Compute highlight (checked), Auto compute (unchecked)
- Island neighborhood:** Single neighbor (selected), Several neighbors (unselected)
- Neighbor border length threshold:** 25%
- Output Label:** New (selected), Overwrite (unselected)
- Apply to:** Volume (selected), Current slice (unselected), All slices (unselected)

The 'Compute Label' button is highlighted in blue. The 3D view on the right shows a chocolate bar cross-section with a green grid overlay and yellow arrows pointing to small islands within the material.

Segmentation Editor: AI-Assisted Segmentation



Segmentation Editor: AI-Assisted Segmentation

The screenshot displays the Segmentation Editor interface. The top menu bar includes File, Window, and Help. Below it, the Segmentation tab is highlighted with a green box and labeled '1'. The main workspace shows a cryo-EM tomogram slice with a red vertical line and a green horizontal line. A green arrow labeled '2' points to the 'Create New Label' button in the Segmentation panel. The Segmentation panel includes fields for Grayscale Image (CryoTomo.am), Label Image (CryoTomo.labels*), and Patch Set (NO SOURCE). Below these are options to 'Create New Material' and a list of materials: Exterior (black) and Material1 (yellow). The 'Assign Selection to Material' section shows Material1 selected. The Masking section has a Range of 55551 to 65535. The Automated Segmentation Tools panel is visible at the bottom left. The bottom right corner shows 'Apply to' options (Current slice, All slices, Volume) and a 'Compute Label' button. A green arrow points to the 'Camera Mode On' button in the top right corner.

Segmentation Editor: AI-Assisted Segmentation

The screenshot displays the Segmentation Editor software interface. The main window shows a cryo-EM image of a biological specimen, likely a cell, with a grid overlay. The interface includes a menu bar (File, Window, Help) and a toolbar with various tools. The left sidebar contains the Segmentation panel, which is currently active. It shows the following settings:

- Grayscale Image: CryoTomo.am
- Label Image: CryoTomo.labels* (with a "Create New Label" button)
- Patch Set: NO SOURCE (with a "Create New Patch Set" button, highlighted by a green arrow and the number 3)

Below these settings is the "Create New Material" section, which lists materials: Exterior (black) and Material1 (yellow). The "Assign Selection to Material" section shows Material1 is selected. The "Masking" section shows a range of 55551 to 65535. The "Automated Segmentation Tools" section includes icons for various tools. At the bottom, the "Apply to" section is set to "Volume".

A dialog box titled "Am Dialog" is open in the center of the image, with the following text:

Choose the size of patches
The size of patches are multiple of 32
96
OK

The "OK" button in the dialog box is highlighted with a green box. A green arrow points from the "Create New Patch Set" button in the Segmentation panel to the dialog box.

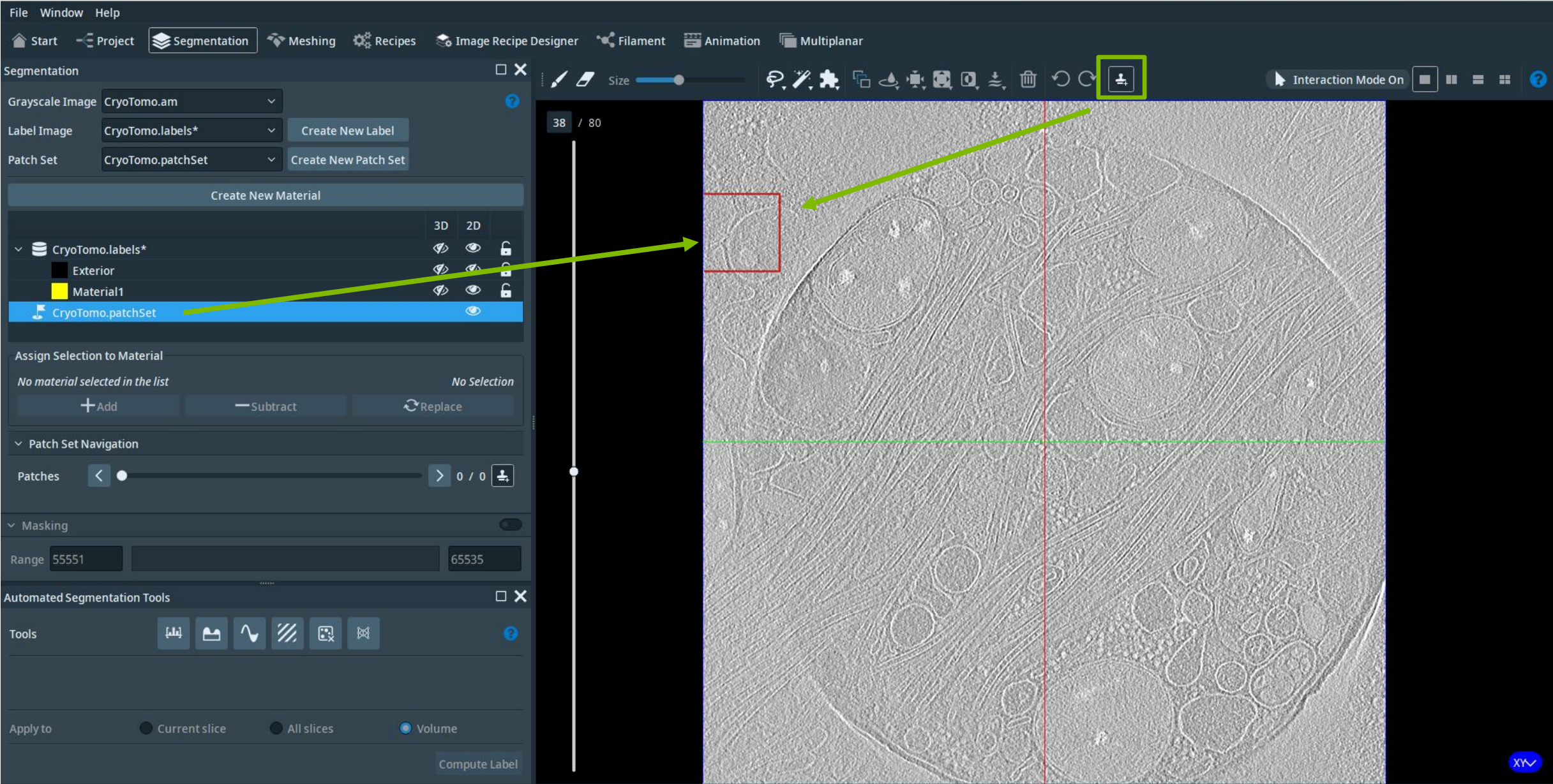
Segmentation Editor: AI-Assisted Segmentation

The screenshot displays the Segmentation Editor interface. The top menu bar includes File, Window, and Help. Below it, a navigation bar shows Start, Project, Segmentation (active), Meshing, Recipes, Image Recipe Designer, Filament, Animation, and Multiplanar. The Segmentation panel on the left contains the following sections:

- Grayscale Image:** CryoTomo.am
- Label Image:** CryoTomo.labels* (with a 'Create New Label' button)
- Patch Set:** CryoTomo.patchSet (with a 'Create New Patch Set' button)
- Create New Material:** A list of materials including 'Exterior' (black) and 'Material1' (yellow). A green arrow points from the 'CryoTomo.patchSet' dropdown to 'Material1'.
- Assign Selection to Material:** 'No material selected in the list' with 'Add', 'Subtract', and 'Replace' buttons.
- Patch Set Navigation:** A slider for 'Patches' set to 0 / 0.
- Masking:** A range of 55551 to 65535.
- Automated Segmentation Tools:** A toolbar with various tool icons.
- Apply to:** Radio buttons for 'Current slice', 'All slices', and 'Volume' (selected).
- Compute Label:** A button at the bottom right of the panel.

The main 3D view shows a cryo-EM volume with a vertical red line and a horizontal green line. A green arrow points from the 'CryoTomo.patchSet' dropdown to the top toolbar. The bottom right corner features a 'XYV' icon.

Segmentation Editor: AI-Assisted Segmentation



Segmentation Editor: AI-Assisted Segmentation



File Window Help

Start Project Segmentation Meshing Recipes Image Recipe Designer Filament Animation Multiplanar

Segmentation

Grayscale Image CryoTomo.am

Label Image CryoTomo.labels* Create New Label

Patch Set CryoTomo.patchSet* Create New Patch Set

Create New Material

	3D	2D	
CryoTomo.labels*	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Exterior	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Material1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CryoTomo.patchSet*	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Assign Selection to Material

No material selected in the list No Selection

+ Add - Subtract Replace

Patch Set Navigation

Patches 6 / 6

Masking

Range 55551 65535

Automated Segmentation Tools

Tools

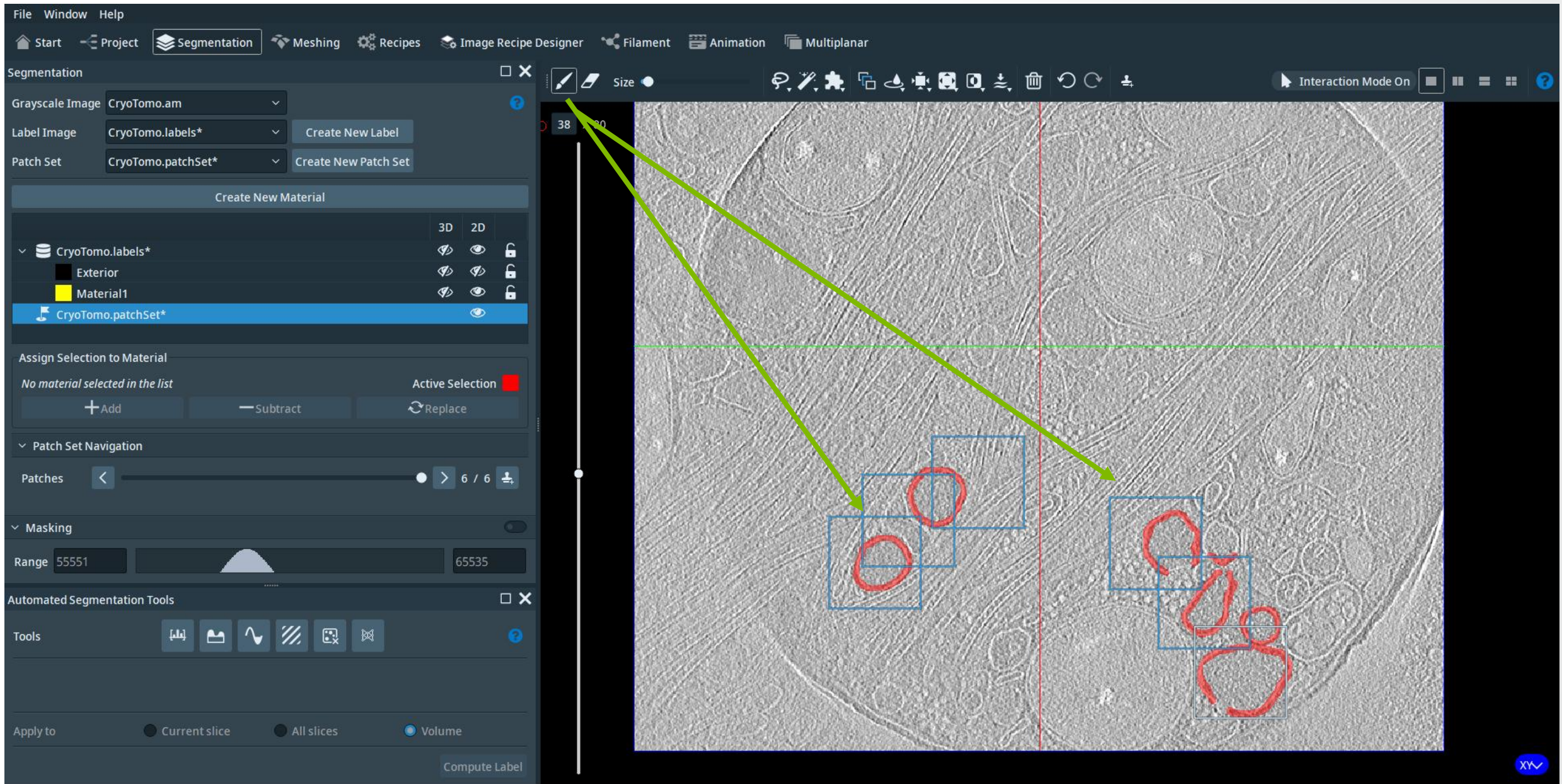
Apply to Current slice All slices Volume

Compute Label

38 / 80

Camera Mode On

Segmentation Editor: AI-Assisted Segmentation



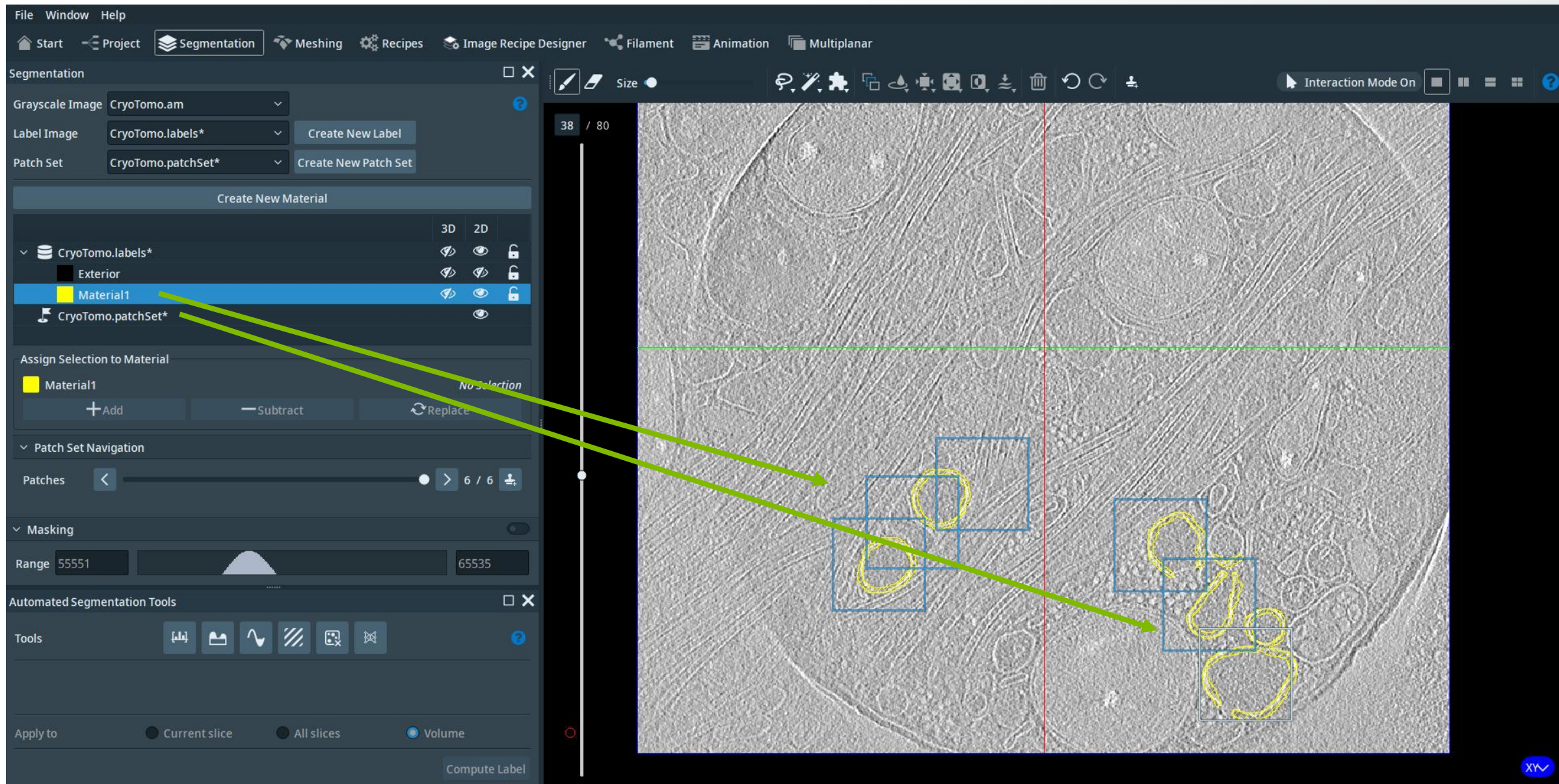
Segmentation Editor: AI-Assisted Segmentation

The screenshot displays the Segmentation Editor software interface. The main window shows a 2D grayscale image of a biological sample, likely a cell, with several regions segmented in red and blue. The interface includes a menu bar (File, Window, Help) and a toolbar with various tools. The Segmentation panel on the left contains the following sections:

- Grayscale Image:** CryoTomo.am
- Label Image:** CryoTomo.labels* (with a "Create New Label" button)
- Patch Set:** CryoTomo.patchSet* (with a "Create New Patch Set" button)
- Create New Material:** A list of materials including "Exterior" and "Material1" (highlighted in blue).
- Assign Selection to Material:** A section with a yellow selection box and buttons for "+ Add", "- Subtract", and "Replace".
- Patch Set Navigation:** A slider showing "Patches" 6 / 6.
- Masking:** A range of 55551 to 65535.
- Automated Segmentation Tools:** A set of icons for various tools.
- Apply to:** Radio buttons for "Current slice", "All slices", and "Volume" (selected).
- Compute Label:** A button at the bottom right of the panel.

Green arrows point from the "Add" button in the "Assign Selection to Material" section to the segmented regions in the main image. A red vertical line and a green horizontal line are visible on the image, indicating the current slice and mask respectively. The bottom right corner features a small "XYW" logo.

Segmentation Editor: AI-Assisted Segmentation



Segmentation Editor: AI-Assisted Segmentation

The screenshot displays the Segmentation Editor interface. The top menu bar includes File, Window, and Help. Below it is a navigation bar with tabs for Start, Project, Segmentation (active), Meshing, Recipes, Image Recipe Designer, Filament, Animation, and Multiplanar. The Segmentation panel on the left contains the following sections:

- Grayscale Image:** CryoTomo.am
- Label Image:** CryoTomo.labels* (with a "Create New Label" button)
- Patch Set:** CryoTomo.patchSet* (with a "Create New Patch Set" button)
- Create New Material:** A list of materials including "Exterior" and "Material1" (highlighted in blue).
- Assign Selection to Material:** A dropdown menu showing "Material1" and "No Selection", with buttons for "+ Add", "- Subtract", and "Replace".
- Patch Set Navigation:** A slider for "Patches" set to 6 / 20.
- Masking:** A range input field showing 55551 to 65535.
- Automated Segmentation Tools:** A toolbar with icons for various segmentation tools.
- Apply to:** Radio buttons for "Current slice", "All slices", and "Volume" (selected).
- Compute Label:** A button at the bottom of the panel.

The main 3D view shows a grayscale volume with a red vertical plane and a green horizontal plane. Numerous blue rectangular boxes are overlaid on the volume, representing segmented regions. Some of these regions are highlighted with yellow circles. A green box highlights a button in the top toolbar, with green arrows pointing to several of the blue boxes in the 3D view. The bottom right corner of the interface features a small blue logo with the letters "XV".

Segmentation Editor: AI-Assisted Segmentation

The screenshot displays the Segmentation Editor software interface. The main view shows a cryo-EM tomogram with a grid of patches. A vertical red line and a horizontal green line intersect at the center. Several patches are outlined in blue, and some are further outlined in yellow. The interface includes a menu bar (File, Window, Help) and a toolbar with various icons. The Segmentation panel on the left contains the following sections:

- Segmentation**: Grayscale Image (CryoTomo.am), Label Image (CryoTomo.labels*), Patch Set (CryoTomo.patchSet*), and buttons for 'Create New Label' and 'Create New Patch Set'.
- Create New Material**: A section for creating new materials.
- Material List**: A list of materials, including 'Exterior'.
- Assign Selection to Material**: A section for assigning selections to materials, with a 'Material1' button and 'No Selection' text.
- Patch Set Navigation**: A section for navigating through patches, showing 'Patches 6 / 20'.
- Masking**: A section for masking, with a 'Range' field set to '55551' to '65535'.
- Automated Segmentation Tools**: A section for automated segmentation tools, with a green arrow pointing to the AI Assisted Segmentation tool icon.
- AI Assisted Segmentation**: A section for AI-assisted segmentation, with parameters for Patch Size (96 x 96 px), Epochs (20), Elastic Deformation Strength (3.00), and Material (Material1).
- Apply to**: A section for applying the segmentation, with radio buttons for 'Current slice', 'All slices', and 'Volume'.

A 'Create Selection' button is highlighted in a green box at the bottom of the AI Assisted Segmentation section.

Segmentation Editor: AI-Assisted Segmentation

The screenshot displays the Segmentation Editor software interface. The top menu bar includes File, Window, and Help. Below it, a navigation bar shows Start, Project, Segmentation (active), Meshing, Recipes, Image Recipe Designer, Filament, Animation, and Multiplanar. The Segmentation panel on the left contains the following sections:

- Grayscale Image:** CryoTomo.am
- Label Image:** CryoTomo.labels* (with a 'Create New Label' button)
- Patch Set:** CryoTomo.patchSet* (with a 'Create New Patch Set' button)
- Create New Material:** A section for managing materials, currently showing 'CryoTomo.labels*' with a sub-entry 'Exterior'. It includes 'Assign Selection to Material' buttons: '+Add' (highlighted with a green box), '-Subtract', and 'Replace'. There is also an 'Active Selection' indicator.
- Patch Set Navigation:** Shows 'Patches' 6 / 20.
- Masking:** Range 5551 to 65535.
- Automated Segmentation Tools:** Includes icons for various tools and a sub-section for 'AI Assisted Segmentation' with parameters:
 - Patch Size: 96 x 96 px
 - Epochs: 20
 - Elastic Deformation Strength: 3.00
 - Material: Material1
- Apply to:** Radio buttons for 'Current slice', 'All slices', and 'Volume' (selected).
- Create Selection:** A blue button at the bottom of the panel.

The main view shows a grayscale cryo-EM image of a biological specimen. A vertical red line and a horizontal green line intersect at the center. Numerous blue rectangular boxes are overlaid on the image, representing patches. Several green arrows point to specific features within these patches. Some patches contain yellow and orange outlines, indicating AI-assisted segmentation results. The interface also shows a 'Camera Mode On' indicator and a '38 / 80' slice indicator.

Segmentation Editor: AI-Assisted Segmentation

The screenshot displays the Segmentation Editor software interface. The top menu bar includes File, Window, and Help. Below it, a navigation bar shows Start, Project, Segmentation (active), Meshing, Recipes, Image Recipe Designer, Filament, Animation, and Multiplanar. The Segmentation panel on the left contains the following sections:

- Grayscale Image:** CryoTomo.am
- Label Image:** CryoTomo.labels* (with a "Create New Label" button)
- Patch Set:** CryoTomo.patchSet* (with a "Create New Patch Set" button)
- Create New Material:** A section for defining materials, currently showing "CryoTomo.labels*" with "Exterior" as a sub-label.
- Assign Selection to Material:** A section for assigning selections to materials, currently showing "Material1" with "No Selection" assigned.
- Patch Set Navigation:** A slider for navigating through patches, currently at 6 / 20.
- Masking:** A section for masking, currently showing a range of 5551 to 65535.
- Automated Segmentation Tools:** A section for automated segmentation, currently showing "AI Assisted Segmentation" with settings for Patch Size (96 x 96 px), Epochs (20), Elastic Deformation Strength (3.00), and Material (Material1).

The main view shows a cryo-EM tomogram with a grid of blue rectangular patches overlaid. A vertical red line and a horizontal green line intersect at the center of the grid. The interface also includes a toolbar with various tools, a "Camera Mode On" indicator, and a "Create Selection" button at the bottom right.

Segmentation Editor: AI-Assisted Segmentation

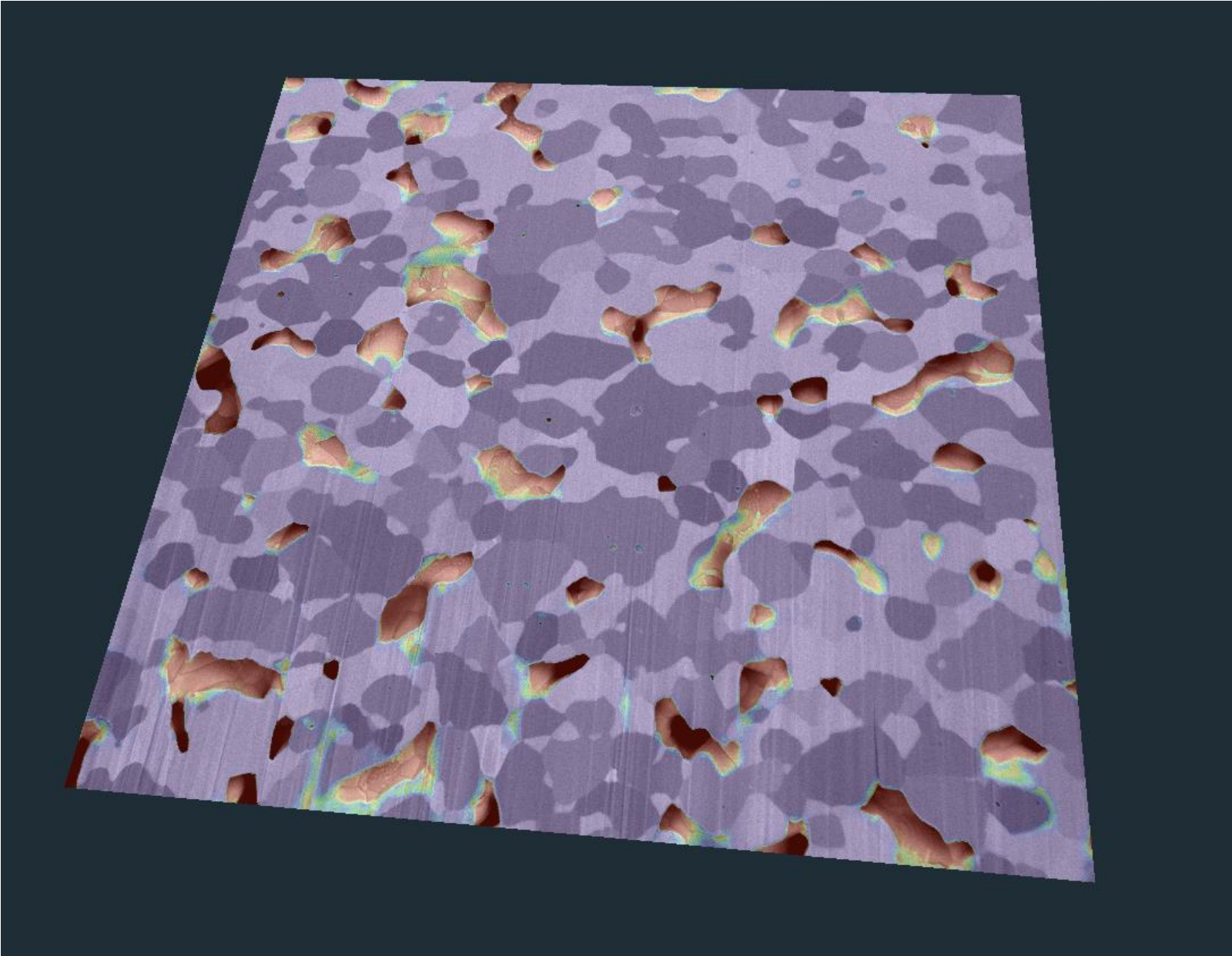
The image displays the Segmentation Editor software interface, which is used for AI-assisted segmentation of cryo-EM data. The interface is divided into several panels:

- Top Menu:** File, Window, Help.
- Navigation Bar:** Start, Project, Segmentation, Meshing, Recipes, Image Recipe Designer, Filament, Animation, Multiplanar.
- Segmentation Panel (Left):**
 - Grayscale Image: CryoTomo.am
 - Label Image: CryoTomo.labels* (with 'Create New Label' button)
 - Patch Set: CryoTomo.patchSet* (with 'Create New Patch Set' button)
 - 'Create New Material' section with 3D/2D view toggles.
 - Material list: Material1 (selected), CryoTomo.patchSet*.
 - 'Assign Selection to Material' section with 'Material1' and 'No Selection' options, and '+ Add', '- Subtract', 'Replace' buttons.
 - 'Patch Set Navigation' section with 'Patches' slider (6 / 20).
 - 'Masking' section with 'Range' input (55551 to 65535).
 - 'Automated Segmentation Tools' section with various tool icons.
 - 'AI Assisted Segmentation' section with settings: Patch Size (96 x 96 px), Epochs (20), Elastic Deformation Strength (3.00), and Material (Material1).
 - 'Apply to' section with radio buttons for 'Current slice', 'All slices', and 'Volume' (selected).
 - 'Create Selection' button.
- Main View (Center):** A 3D visualization of a segmented volume (yellow) with a blue bounding box and red/green axes. A '3D' icon is at the bottom right.
- Right Panel:** A 2D slice view (38 / 80) showing the original grayscale image with blue bounding boxes and yellow segmentation masks. A 'Camera Mode On' button is at the top right.

Segmentation Editor: AI-Assisted Segmentation



Segmentation Editor: AI-Assisted Segmentation



Segmentation Editor: AI-Assisted Segmentation

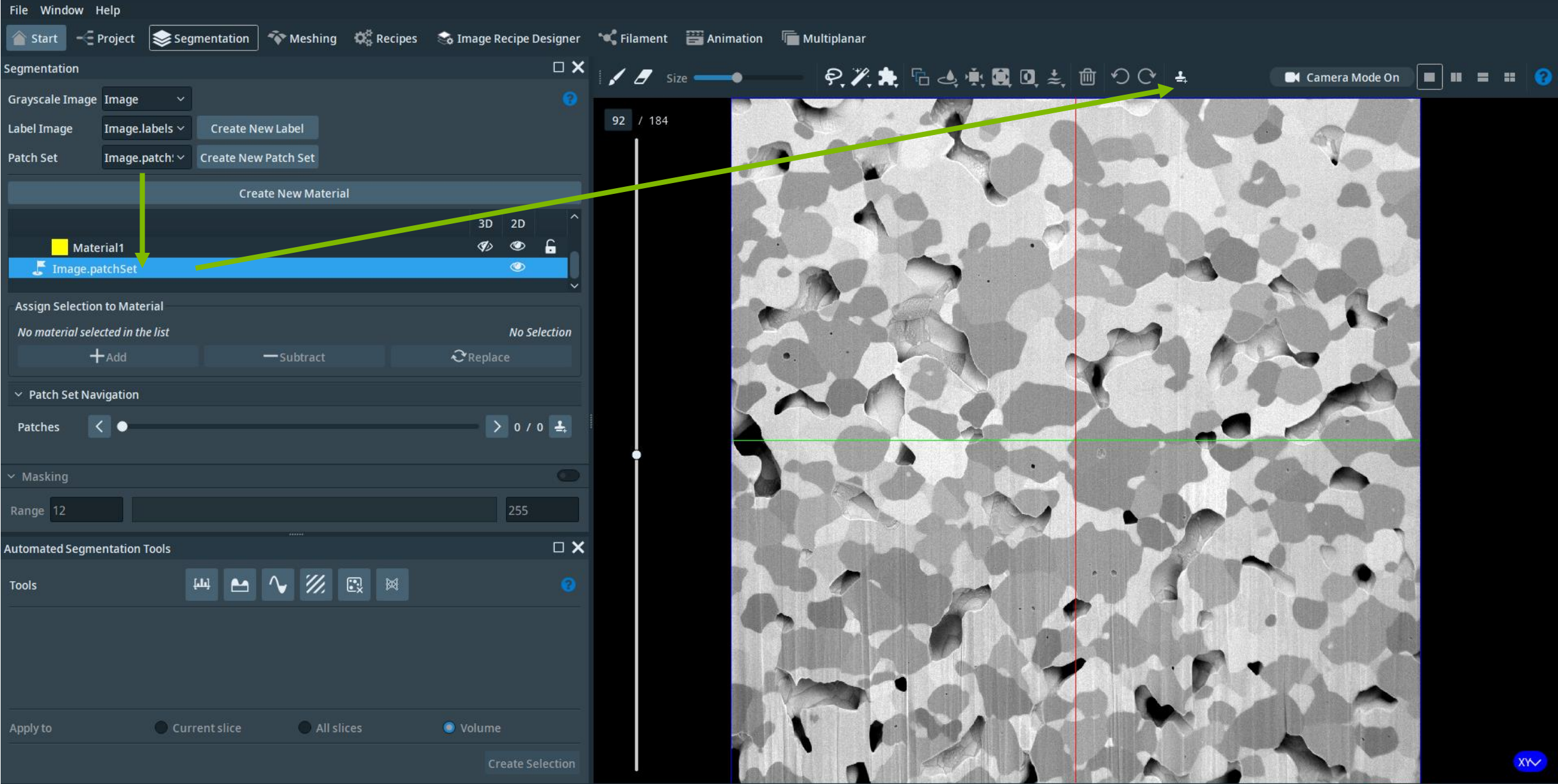
The screenshot displays the Segmentation Editor software interface. The main window shows a 3D visualization of a porous material structure, with a vertical red line and a horizontal green line intersecting at the center. The interface includes a top menu bar with 'File', 'Window', and 'Help'. Below the menu bar, there are navigation tabs for 'Start', 'Project', 'Segmentation' (highlighted with a green box), 'Meshing', 'Recipes', 'Image Recipe Designer', 'Filament', 'Animation', and 'Multiplanar'. The 'Segmentation' panel on the left contains several sections: 'Grayscale Image' with a dropdown menu and a green arrow labeled '1' pointing to it; 'Label Image' with a dropdown menu and a 'Create New Label' button with a green arrow labeled '2' pointing to it; 'Patch Set' with a dropdown menu and a 'Create New Patch Set' button; 'Create New Material' section with a table of materials; 'Assign Selection to Material' section with a 'Material1' selection and buttons for '+ Add', '- Subtract', and 'Replace'; 'Masking' section with a 'Range' input field set to '12' and a '255' value; 'Automated Segmentation Tools' section with several tool icons; and 'Apply to' section with radio buttons for 'Current slice', 'All slices', and 'Volume' (selected). A 'Create Selection' button is located at the bottom right of the 'Apply to' section. The main 3D view area shows a porous material structure with a vertical red line and a horizontal green line. A green arrow points to the top right corner of the 3D view area. The bottom right corner of the 3D view area features a 'XIV' logo.

	3D	2D
Image.labels*	<input type="checkbox"/>	<input type="checkbox"/>
Exterior	<input type="checkbox"/>	<input type="checkbox"/>
Material1	<input type="checkbox"/>	<input type="checkbox"/>

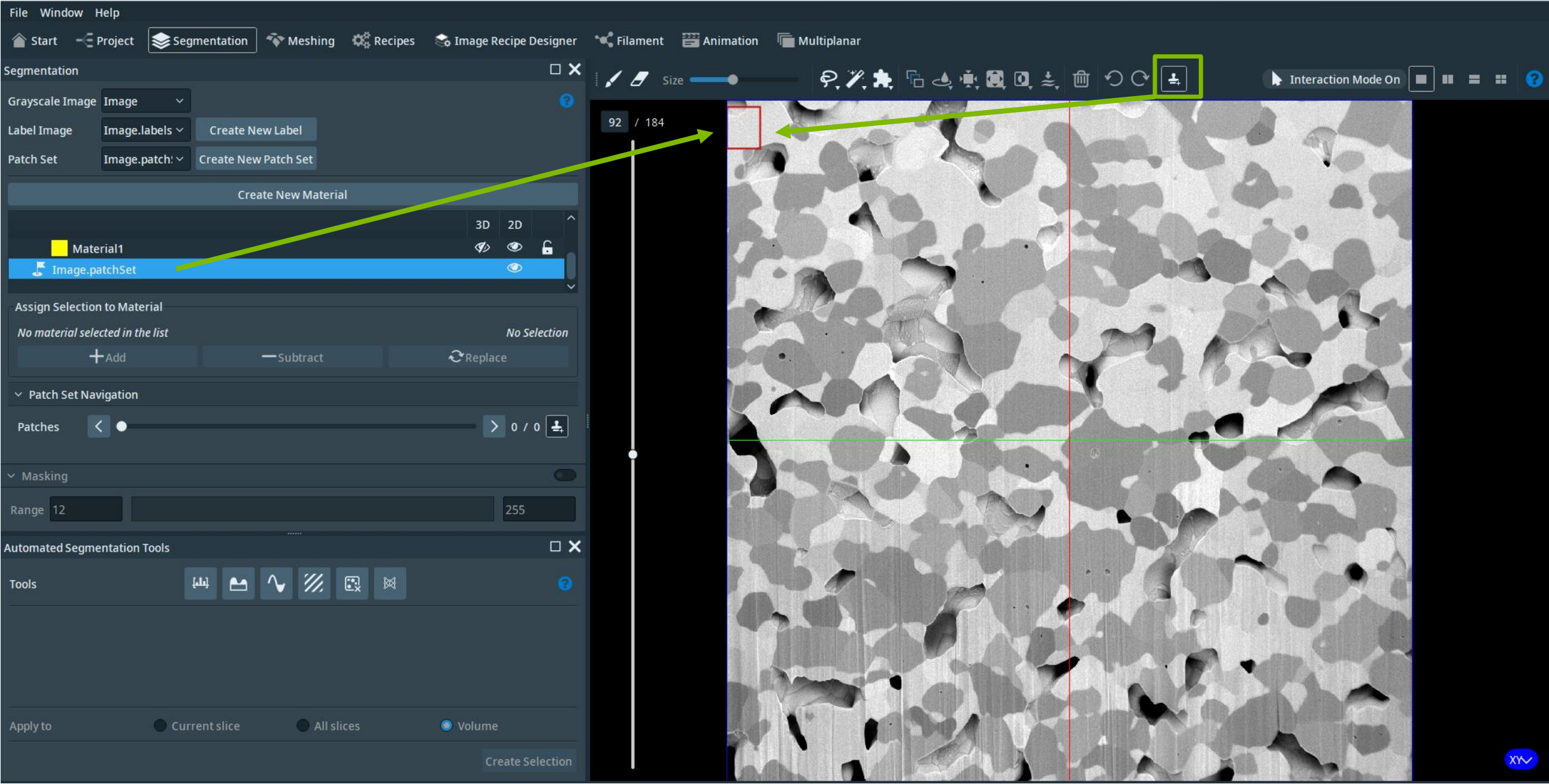
Segmentation Editor: AI-Assisted Segmentation

The screenshot displays the Segmentation Editor interface. On the left, the 'Segmentation' panel shows the 'Patch Set' dropdown set to 'NO SOURCE' and the 'Create New Patch Set' button highlighted with a green arrow and the number '3'. Below this, a list of materials includes 'Exterior' and 'Material1'. The 'Assign Selection to Material' section shows 'Material1' selected. The 'Automated Segmentation Tools' panel is visible at the bottom left. The main view shows a 3D model of a porous material with a vertical red line indicating the current slice (92 / 184). A 'Dialog' box is open, titled 'Choose the size of patches', with the text 'The size of patches are multiple of 32' and a dropdown menu showing '96'. The 'OK' button in the dialog is highlighted with a green box.

Segmentation Editor: AI-Assisted Segmentation



Segmentation Editor: AI-Assisted Segmentation



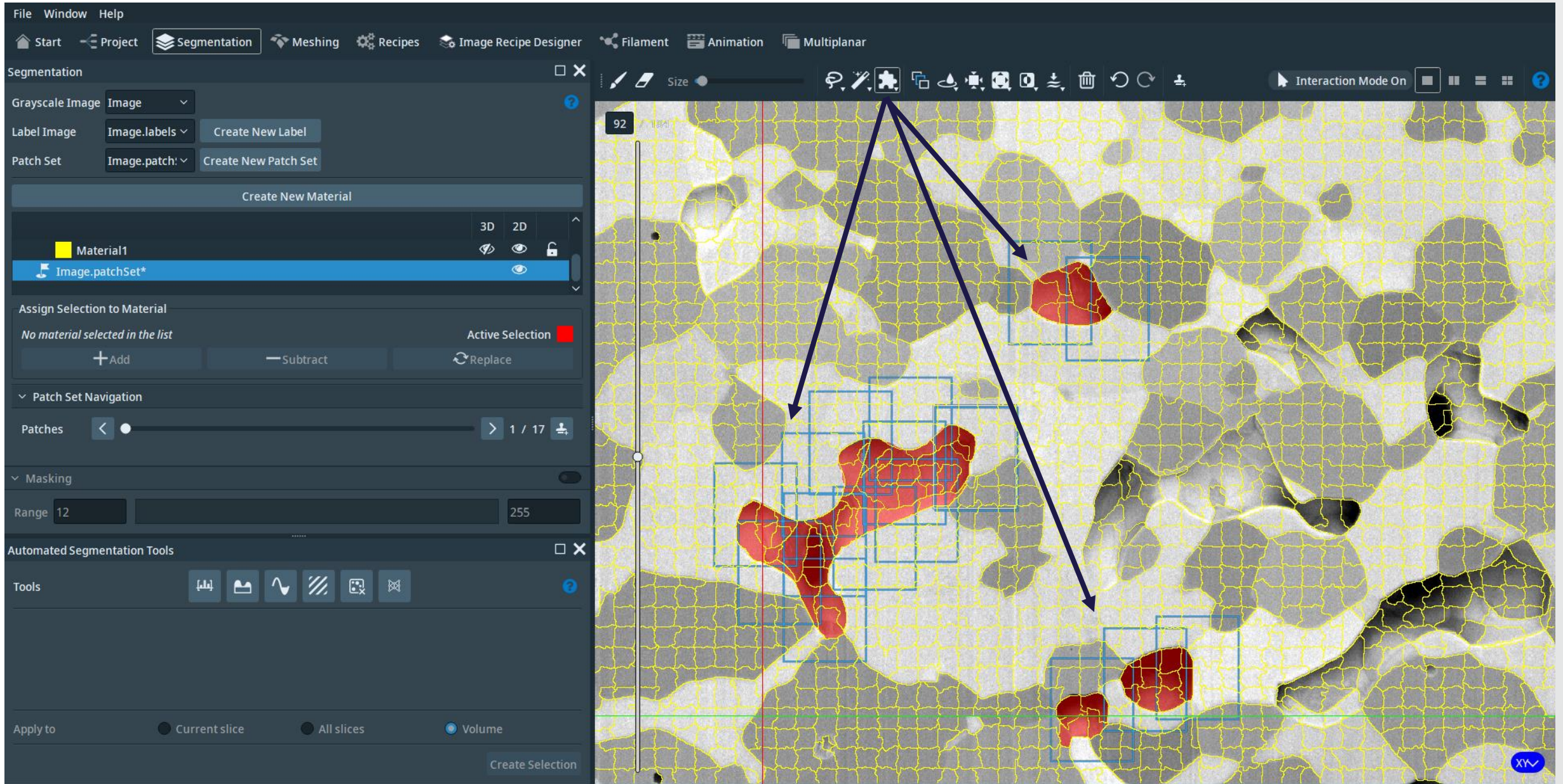
Segmentation Editor: AI-Assisted Segmentation

The image displays the Segmentation Editor software interface. The top menu bar includes File, Window, and Help. Below the menu, there are navigation tabs for Start, Project, Segmentation, Meshing, Recipes, and Image Recipe Designer. The Segmentation panel on the left contains the following sections:

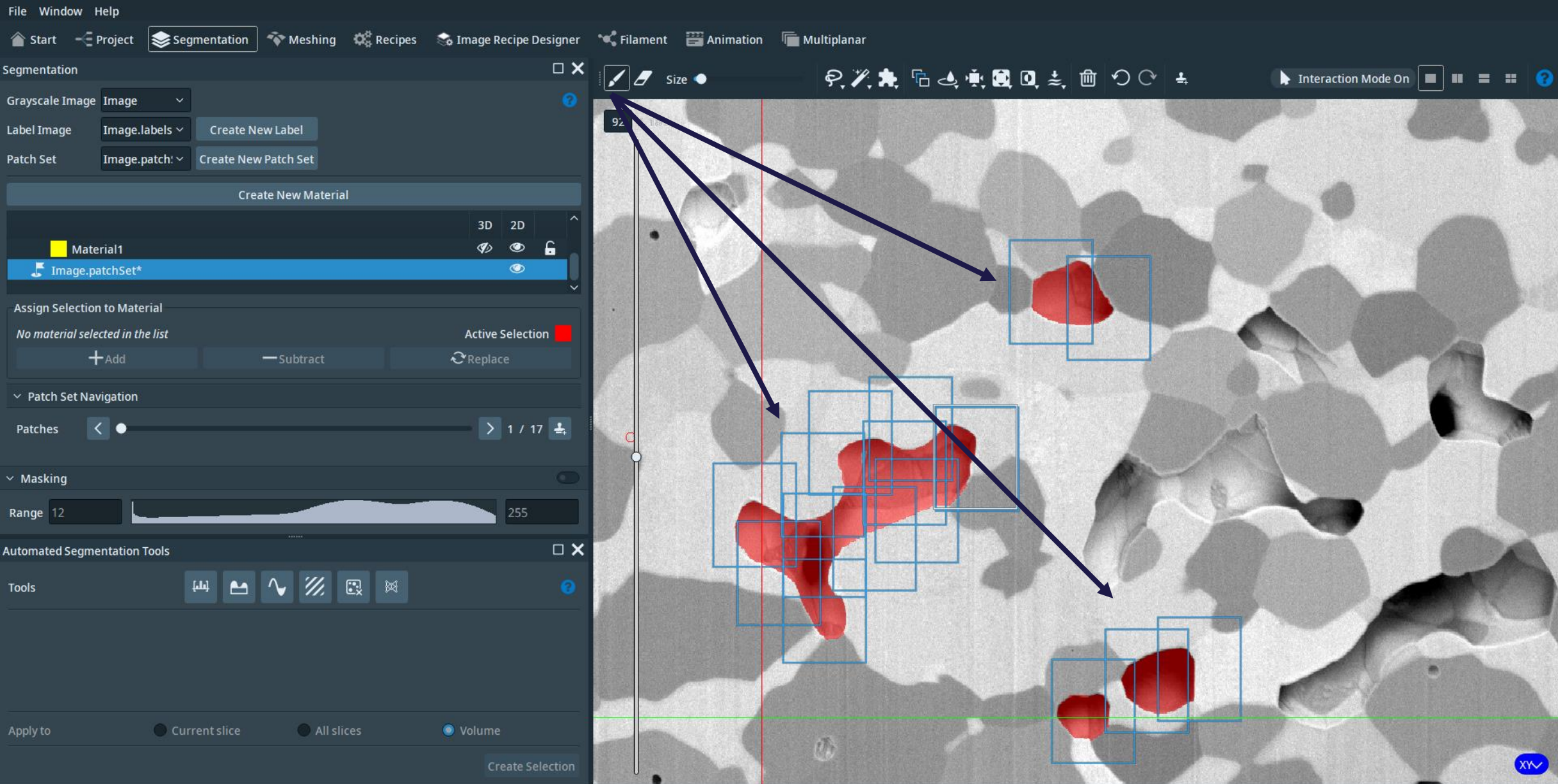
- Grayscale Image:** Image (dropdown)
- Label Image:** Image.labels (dropdown), Create New Label (button)
- Patch Set:** Image.patch (dropdown), Create New Patch Set (button)
- Create New Material:** A list with Material1 and Image.patchSet* (selected).
- Assign Selection to Material:** No material selected in the list, No Selection, + Add, - Subtract, Replace.
- Patch Set Navigation:** Patches, < 1 / 17 >
- Masking:** Range 12 to 255.
- Automated Segmentation Tools:** Tools (brush, eraser, lasso, etc.).
- Apply to:** Current slice, All slices, Volume (selected).
- Create Selection** (button)

The main 3D view shows a grayscale image of a porous material with a red vertical line and a green horizontal line. Blue bounding boxes are overlaid on the image, indicating segmentation regions. The top right of the 3D view shows '92 / 184' and 'Camera Mode On'. The bottom right corner features a 'XY' logo.

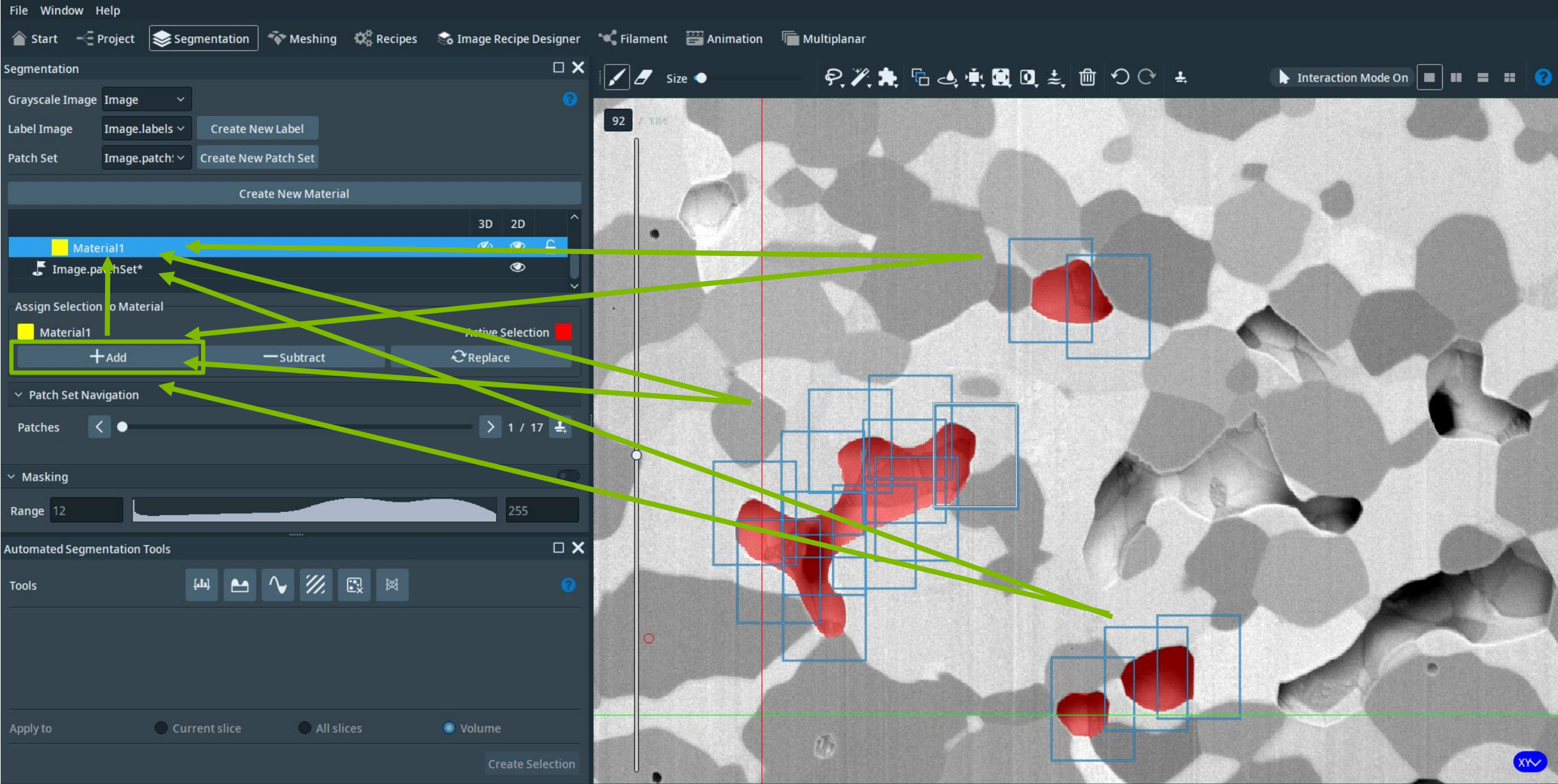
Segmentation Editor: AI-Assisted Segmentation



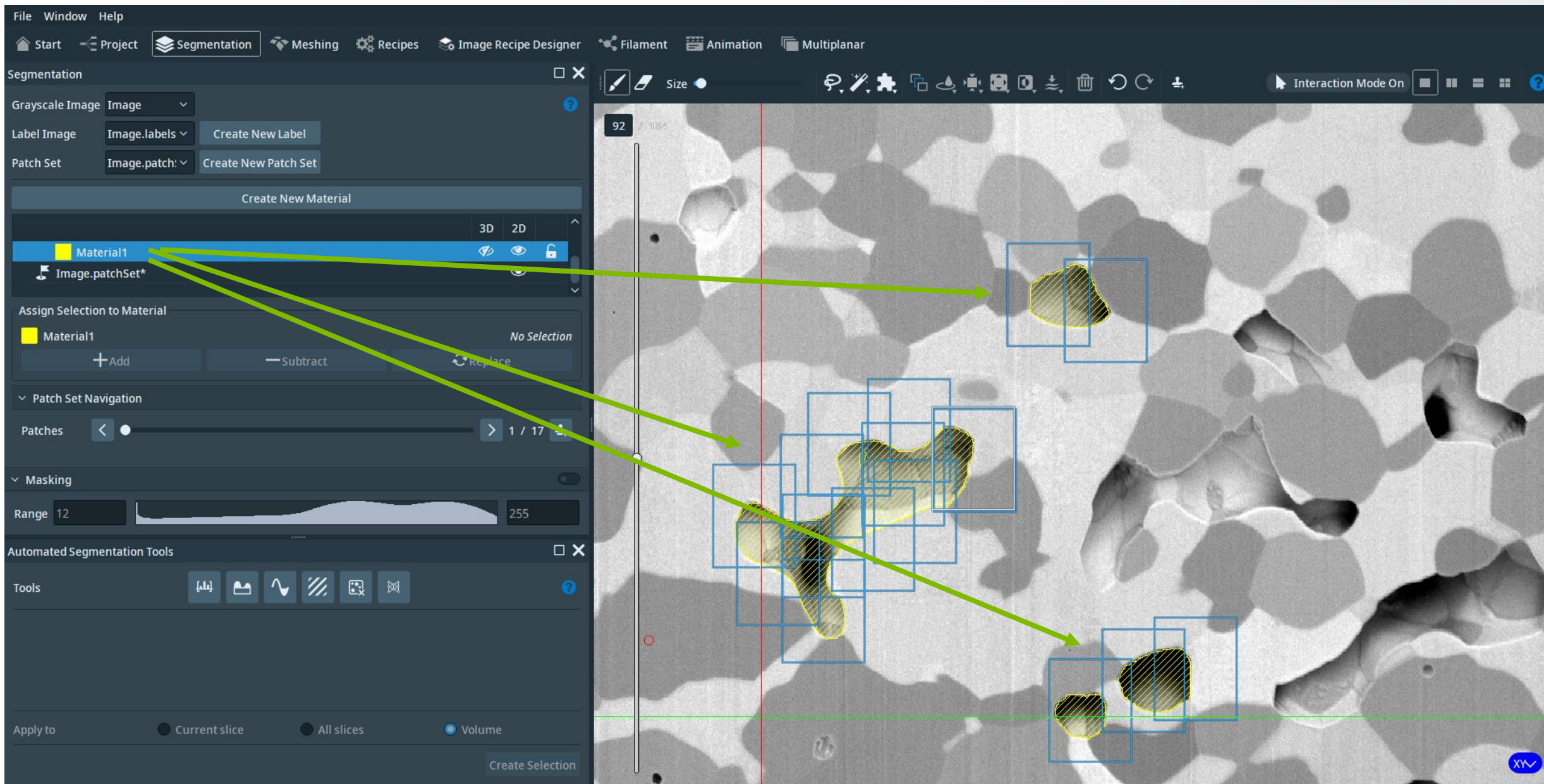
Segmentation Editor: AI-Assisted Segmentation



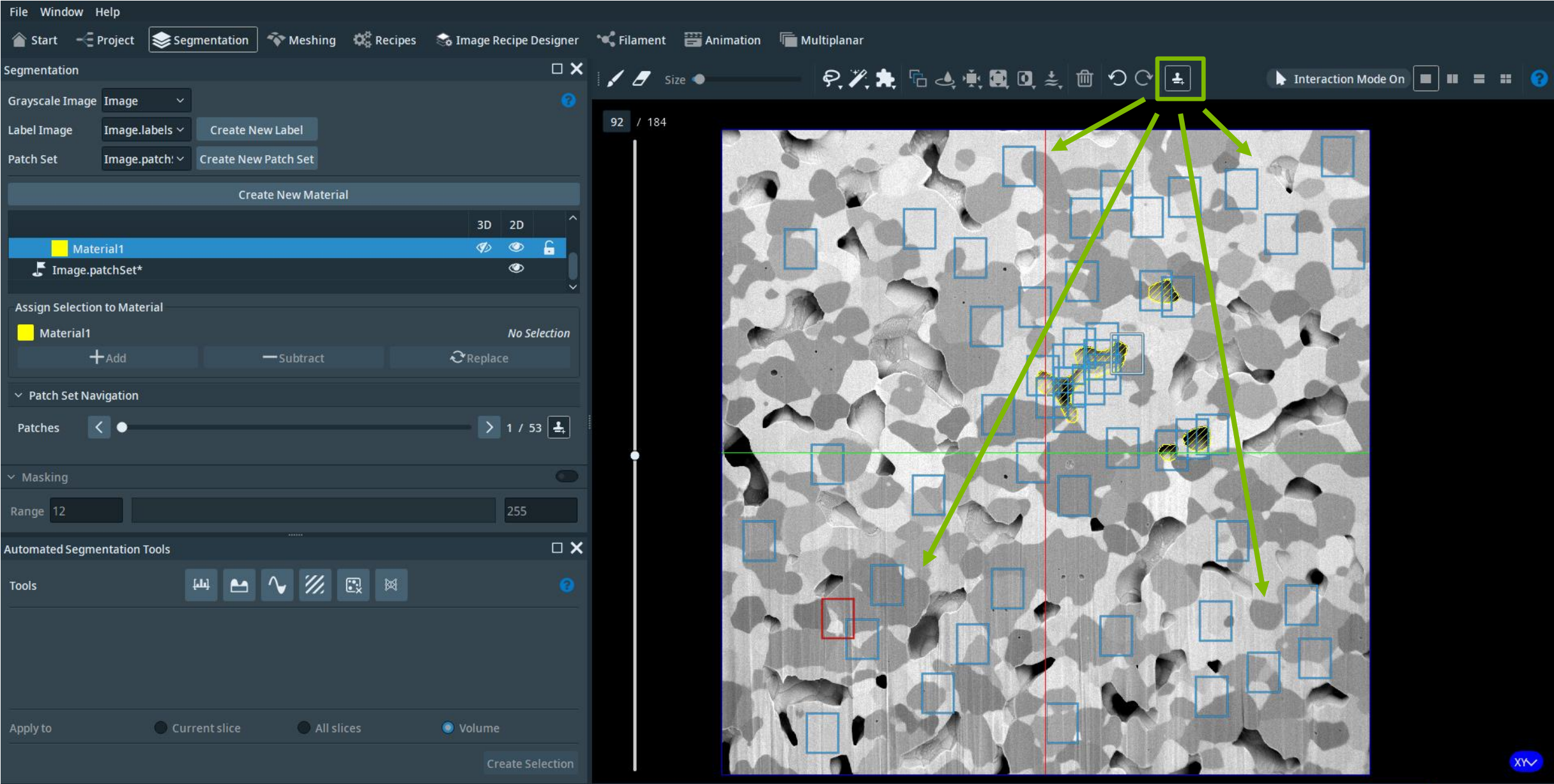
Segmentation Editor: AI-Assisted Segmentation



Segmentation Editor: AI-Assisted Segmentation



Segmentation Editor: AI-Assisted Segmentation



Segmentation Editor: AI-Assisted Segmentation

The screenshot displays the Segmentation Editor software interface. The top menu bar includes File, Window, and Help. Below it is a navigation bar with tabs for Start, Project, Segmentation, Meshing, Recipes, Image Recipe Designer, Filament, Animation, and Multiplanar. The Segmentation panel on the left contains settings for Grayscale Image, Label Image, and Patch Set, along with a 'Create New Material' section. The 'Automated Segmentation Tools' panel is active, showing a toolbar with icons for various tools. A green arrow points to the AI Assisted Segmentation tool icon. Below this, the 'AI Assisted Segmentation' section includes settings for Patch Size (96 x 96 px), Epochs (20), Elastic Deformation Strength (3.00), and Material (Material1). The 'Apply to' section has radio buttons for Current slice, All slices, and Volume (selected). A blue box highlights the 'Create Selection' button at the bottom of the AI Assisted Segmentation panel. The main 3D view area shows a grayscale image of a porous material with numerous blue bounding boxes overlaid, indicating the segmentation process. A vertical red line and a horizontal green line are visible in the 3D view. The bottom right corner features a ThermoFisher Scientific logo.

Segmentation Editor: AI-Assisted Segmentation

The image displays the Segmentation Editor software interface, which is used for AI-assisted segmentation of 3D volumes. The interface is divided into several key sections:

- Menu Bar:** Includes File, Window, and Help.
- Navigation and Tools:** Features buttons for Start, Project, Segmentation, Meshing, Recipes, Image Recipe Designer, Filament, Animation, and Multiplanar. A toolbar at the top right contains various editing tools like brush, eraser, and selection tools, along with a 'Camera Mode On' indicator.
- Segmentation Panel (Left Sidebar):**
 - Grayscale Image:** Set to 'Image'.
 - Label Image:** Set to 'Image.labels', with a 'Create New Label' button.
 - Patch Set:** Set to 'Image.patch', with a 'Create New Patch Set' button.
 - Create New Material:** A section for defining materials, currently showing 'Material1' with 3D and 2D view toggles.
 - Assign Selection to Material:** A section with a '+ Add' button highlighted in green, and 'Subtract' and 'Replace' options.
 - Patch Set Navigation:** Shows 'Patches' 1 / 53.
 - Masking:** Includes a 'Range' slider set from 12 to 255.
 - Automated Segmentation Tools:** A section with icons for various tools and an 'AI Assisted Segmentation' sub-section.
 - AI Assisted Segmentation Settings:**
 - Patch Size: 96 x 96 px
 - Epochs: 20
 - Elastic Deformation Strength: 3.00
 - Material: Material1
 - Apply to: Volume (selected)
 - Create Selection:** A button at the bottom of the sidebar.
- Main View (Right):** A 3D visualization of a volume with red and gray regions. Numerous blue bounding boxes are overlaid on the volume, and several green arrows point to specific regions. A vertical red line and a horizontal green line are also visible on the volume.

Segmentation Editor: AI-Assisted Segmentation

The image displays the Segmentation Editor software interface. The top menu bar includes File, Window, and Help. Below it, a navigation bar shows Start, Project, Segmentation (active), Meshing, Recipes, Image Recipe Designer, Filament, Animation, and Multiplanar. The Segmentation panel on the left contains the following sections:

- Grayscale Image:** Image (dropdown)
- Label Image:** Image.labels (dropdown), Create New Label (button)
- Patch Set:** Image.patch (dropdown), Create New Patch Set (button)
- Create New Material:** A list with 'Material1' selected, showing 3D and 2D view icons and a lock icon.
- Assign Selection to Material:** Material1 (dropdown), No Selection (text), + Add, - Subtract, and Replace (circular arrow) buttons.
- Patch Set Navigation:** Patches (1 / 53) with navigation arrows.
- Masking:** Range (12 to 255) with input fields.
- Automated Segmentation Tools:** A row of icons for various tools.
- AI Assisted Segmentation:** Patch Size (96 x 96 px), Epochs (20), Elastic Deformation Strength (3.00), Material (Material1 dropdown), and Apply to (Current slice, All slices, Volume radio buttons).
- Create Selection:** A blue button at the bottom right of the panel.

The main workspace shows a grayscale image of a porous material. Yellow hatched regions indicate segmented areas, and blue rectangular boxes represent patch sets. A vertical red line and a horizontal green line are overlaid on the image. The top right of the workspace shows 'Camera Mode On' and a help icon. The bottom right corner features a 'XYV' logo.

Segmentation Editor: AI-Assisted Segmentation

The screenshot displays the Segmentation Editor software interface, which is used for AI-assisted segmentation of 3D data. The interface is divided into several key sections:

- Top Menu and Navigation:** Includes 'File', 'Window', and 'Help' menus. Below them are navigation tabs for 'Start', 'Project', 'Segmentation' (active), 'Meshing', 'Recipes', 'Image Recipe Designer', 'Filament', 'Animation', and 'Multiplanar'. A toolbar with various icons for editing and viewing is also present.
- Segmentation Panel (Left):** Contains settings for 'Grayscale Image' (set to 'Image'), 'Label Image' (set to 'Image.labels'), and 'Patch Set' (set to 'Image.patch'). It includes a 'Create New Label' button and a 'Create New Patch Set' button. Below this is a 'Create New Material' section with a list of materials, currently showing 'Material1'. There are also buttons for 'Assign Selection to Material', '+Add', '-Subtract', and 'Replace'.
- AI Assisted Segmentation Panel (Bottom Left):** Features a 'Tools' section with icons for various operations. The 'AI Assisted Segmentation' section includes:
 - Patch Size:** 96 x 96 px
 - Epochs:** 20
 - Elastic Deformation Strength:** 3.00
 - Material:** Material1
 - Apply to:** Radio buttons for 'Current slice', 'All slices', and 'Volume' (selected).
 - Create Selection:** A prominent blue button to execute the segmentation.
- 3D View (Center):** Shows a 3D visualization of the segmented data, with a yellow material highlighted. A red and green line indicate the current slice plane.
- 2D View (Right):** Shows a 2D slice of the data with a grid of blue bounding boxes overlaid on the segmented regions. A vertical line indicates the current slice position, and a '92 / 184' indicator shows the slice number.

Segmentation Editor: AI-Assisted Segmentation

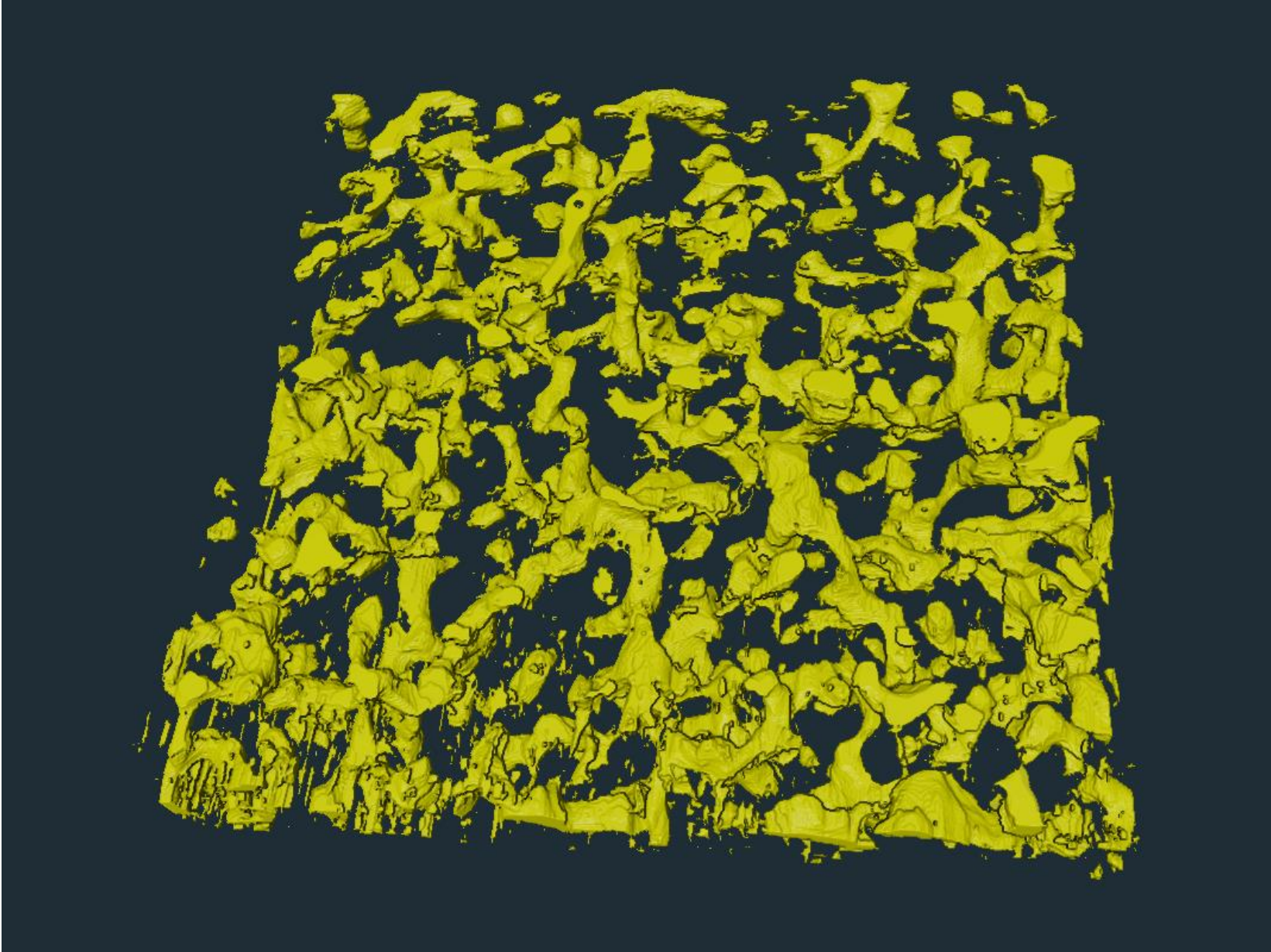


Image segmentation: Segmentation Editor

Segmentation Editor: workroom

Dedicated workroom for interactive segmentation

Image and Label Field

List of materials (labels)

Configuration of display

Selection manipulation

Tools for generating selections

The screenshot shows the Segmentation Editor interface with the following components:

- Menu Bar:** File, Edit, Project, View, Window, XPand, Python, Segmentation, Selection, Help. A green arrow points to the Segmentation menu.
- Toolbar:** Start, Project, Recipes, Segmentation, Meshing, Filament, Animation.
- Segmentation Editor Panel:**
 - Image: chocolate-bar.am
 - Label field: chocolate-bar.labels
 - Buttons: New, Rename, Delete
- MATERIALS Table:**

Color	Name	3D	2D	Colorize	Lock	Select
Grey	Exterior (Not Assigned)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Green	Inside	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
- DISPLAY CONTROL:**
 - 2D: 0, 1910, Edit
 - 3D: 410, 1910, Edit, Option
 - Buttons: Add, Delete, Locate
 - Options: 2D Crosshairs, Crosshairs, Slices, Volume rendering
- SELECTION:**
 - Volume, Current slice, Show in 3D
 - Buttons: Selection tools (brush, eraser, lasso, etc.)
 - Options: All slices, Select all
- 3D Viewport:** XY, XZ, YZ views of a chocolate bar cross-section.
- Status Bar:** Pos: 0.00264 0.01044 0.03192, Index: 23 88 267, Material: Exterior, Intensity: 1198.

Segmentation Editor: workroom

Dedicated workroom for interactive segmentation

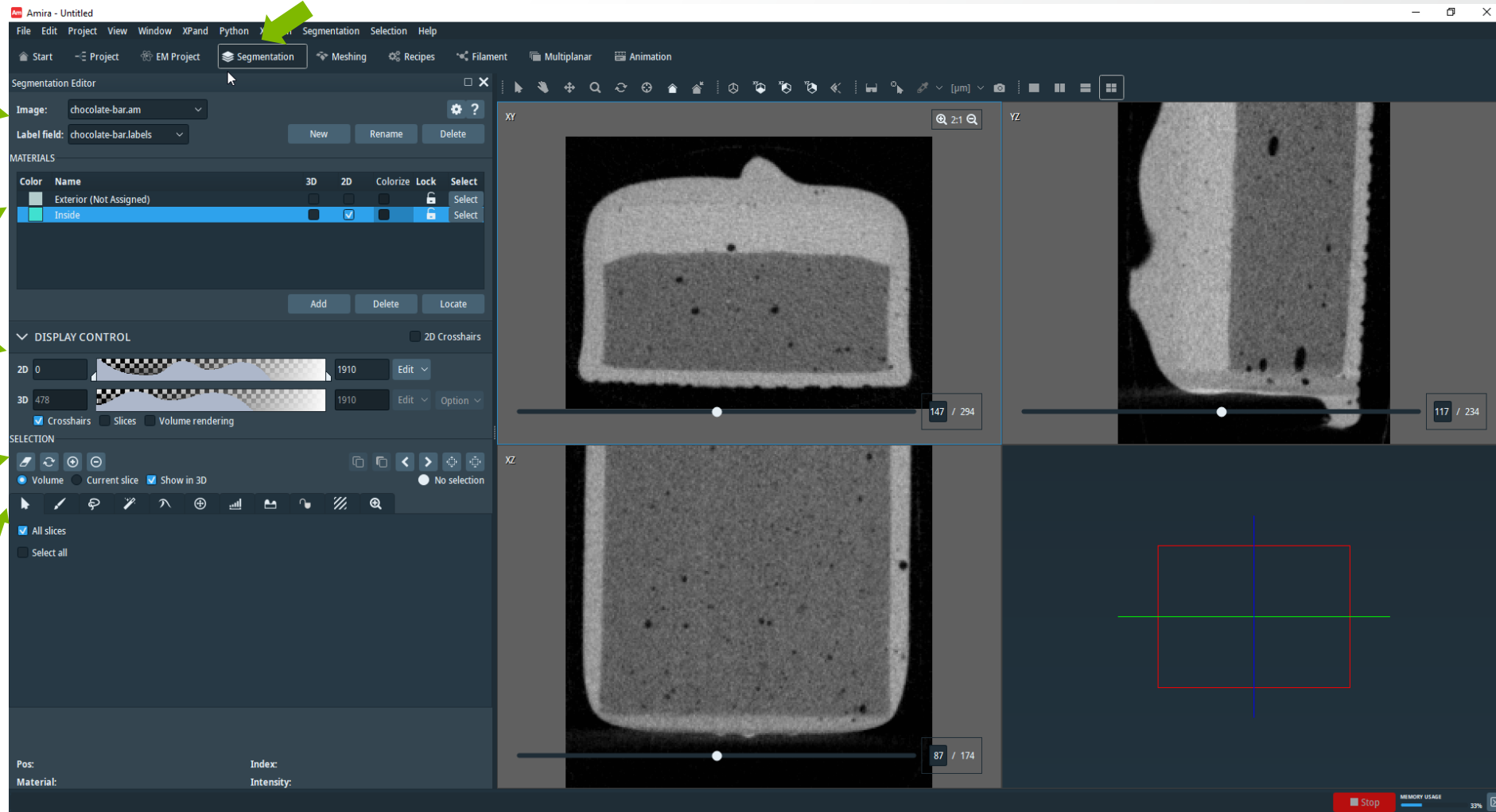
Image and Label Field

List of materials (labels)

Configuration of display

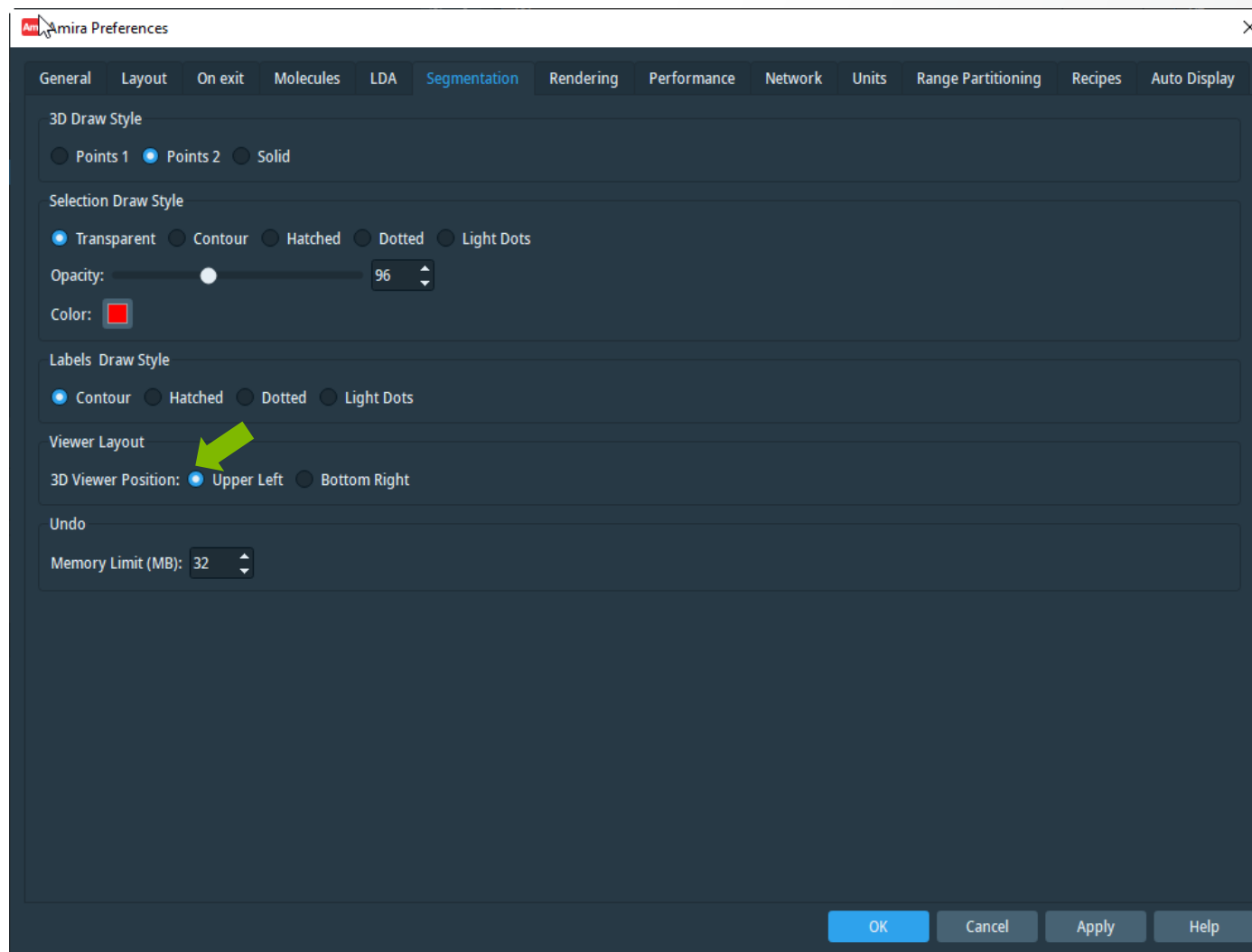
Selection manipulation

Tools for generating selections



Segmentation Editor: 3D Viewer Position

The default **3D Viewer Position** in Amira is “Bottom Right”. You can switch it to “Upper Left” from: Edit -> Preferences -> Segmentation



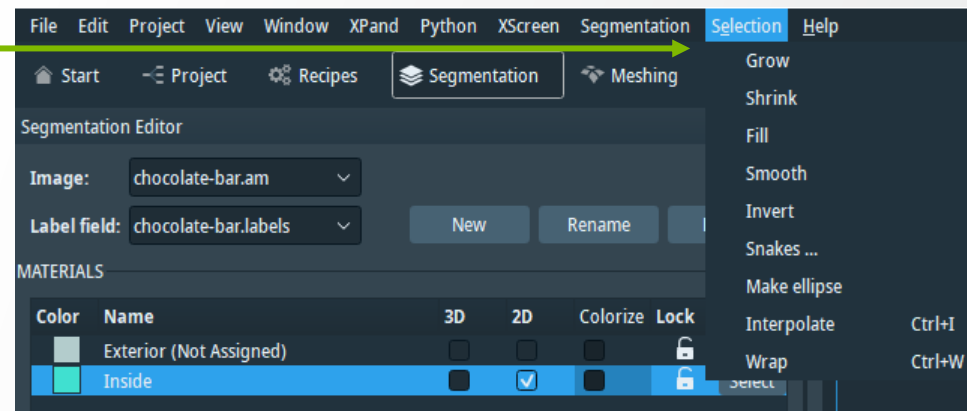
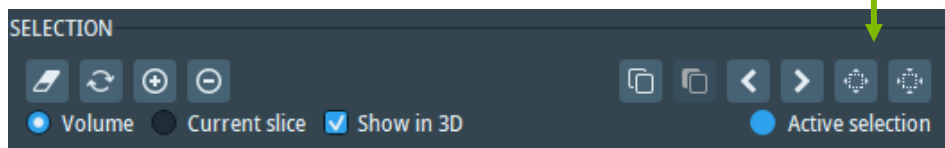
Segmentation Editor: general principle

- **Generate selection** using the tools available in the selection generation toolbar e.g. Brush, Lasso, Magic Wand (region growing), Threshold, Blow



- **Modify selection** using the tools available in the:

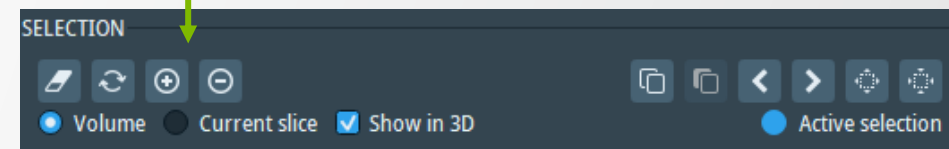
- Selection menu
- With keys (shift/ctrl)
- Selection modification toolbar



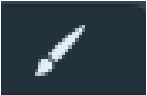


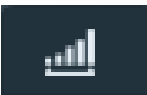


- **Assign selection** to material using the tools available in the selection assignment toolbar

Rules of thumb:

- Only one label per voxel
- Always keep the “Exterior” material



Segmentation Editor: selection tools

-  **Brush:** 2D painting
 - Right click inside close contour: flood fill in 2D
 - CTRL: erase
-  **Lasso:** 2D & 3D closed contours
 - Generate selections in 2D and 3D by defining closed contours
 - “Auto-trace” option: snap to gradient (in 2D)
-  **Pick & Move:** 2D & 3D
 - Pick and move (translate/rotate) selection
 - Can be applied to all slices or current slice only
-  **Threshold:** 2D & 3D masking
 - Select all voxels in intensity range
-  **Magic Wand:**
 - Region growing within intensity range
 - CTRL: add new seeds
 - Draw 2D barriers (“**Draw limit line**” option)
-  **Blow:**
 - Blow a 2D balloon that stick to edges

Segmentation Editor: selection tools

Tips:

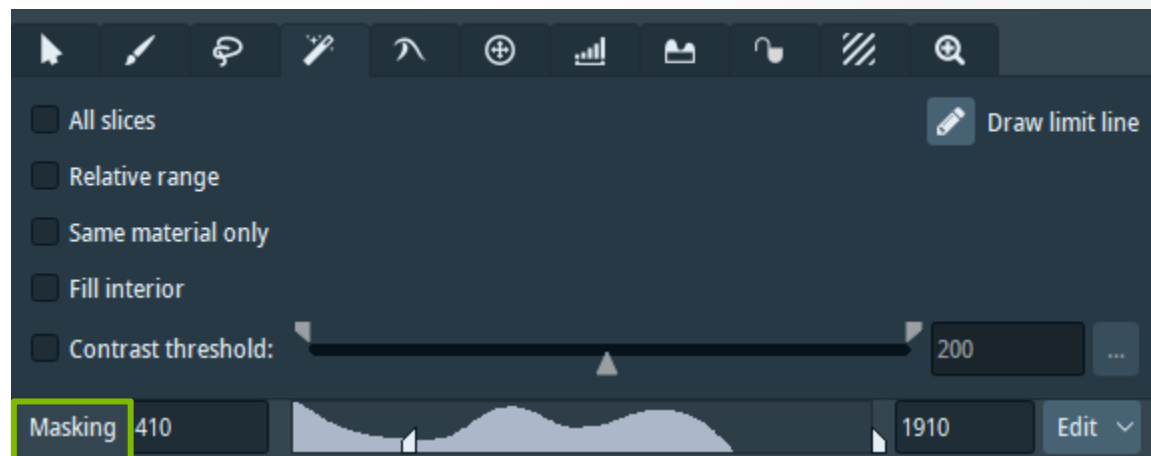
- “**Same Material Only**” option available for: Brush and Magic Wand tools



- “**All Slices**” mode available for: Threshold, Magic Wand and Pick & Move tools



- “**Masking**” can be enabled: selection only within specified intensity range



Segmentation Editor: selection modification

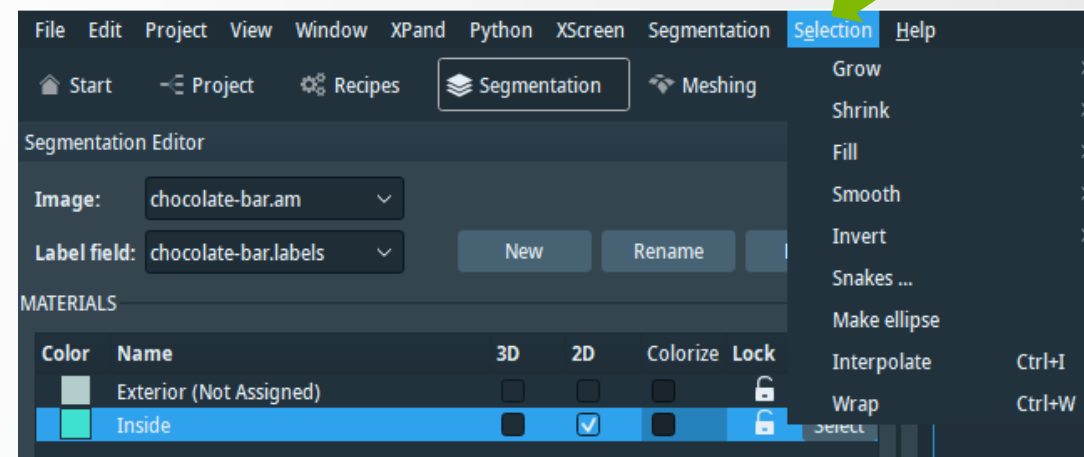
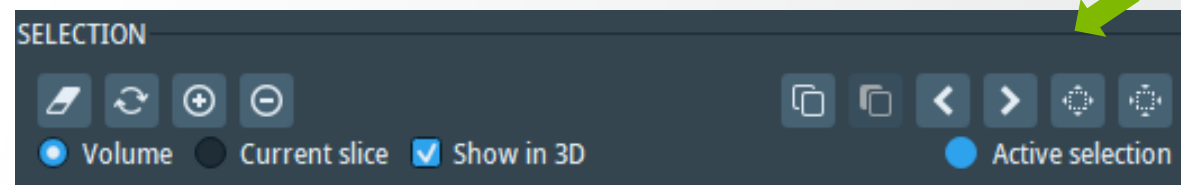
Selection modification

- **Grow / Shrink** (2D or 3D)
- **Fill Holes** (2D or 3D)
- **Smooth** (2D only)
- **Invert** Selection

- **Snake**: propagate a 2D selection to the next/previous slice, following grayscale intensities

- **Interpolate**: between selections from parallel slices
 - Shape-based interpolation

- **Wrap**: between selections from orthogonal slices
 - Shape-based RBF interpolation



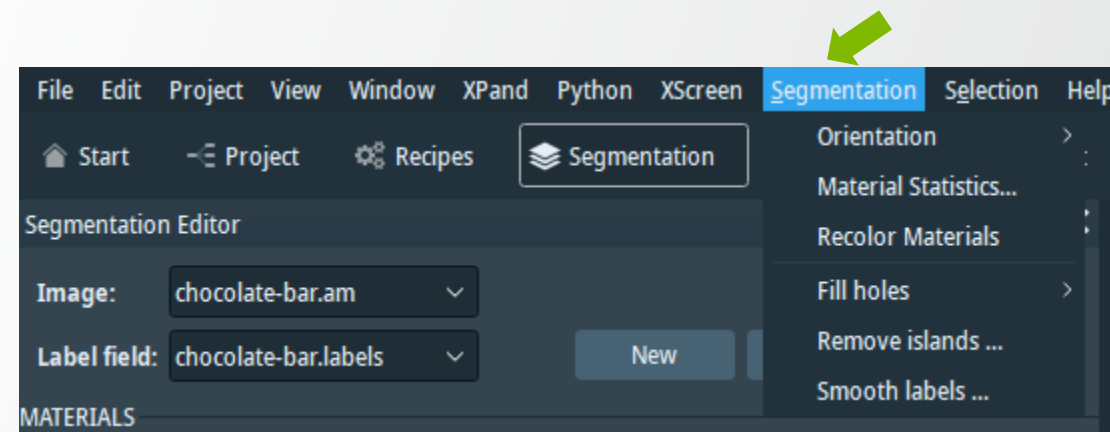
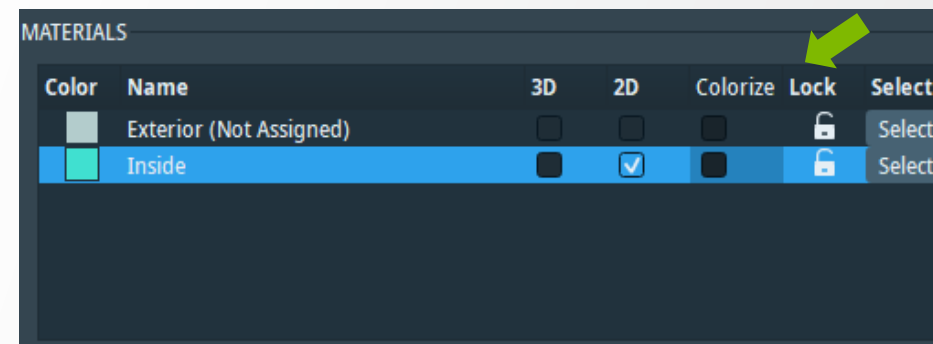
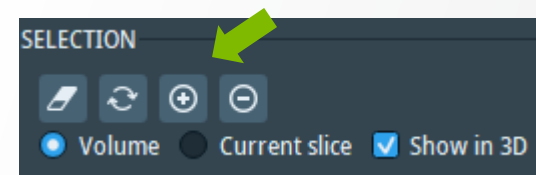
Segmentation Editor: materials assignment and modification tools

Materials assignment:

- Add selection to material (or replace / subtract)
- Materials can be locked

Materials Menu:

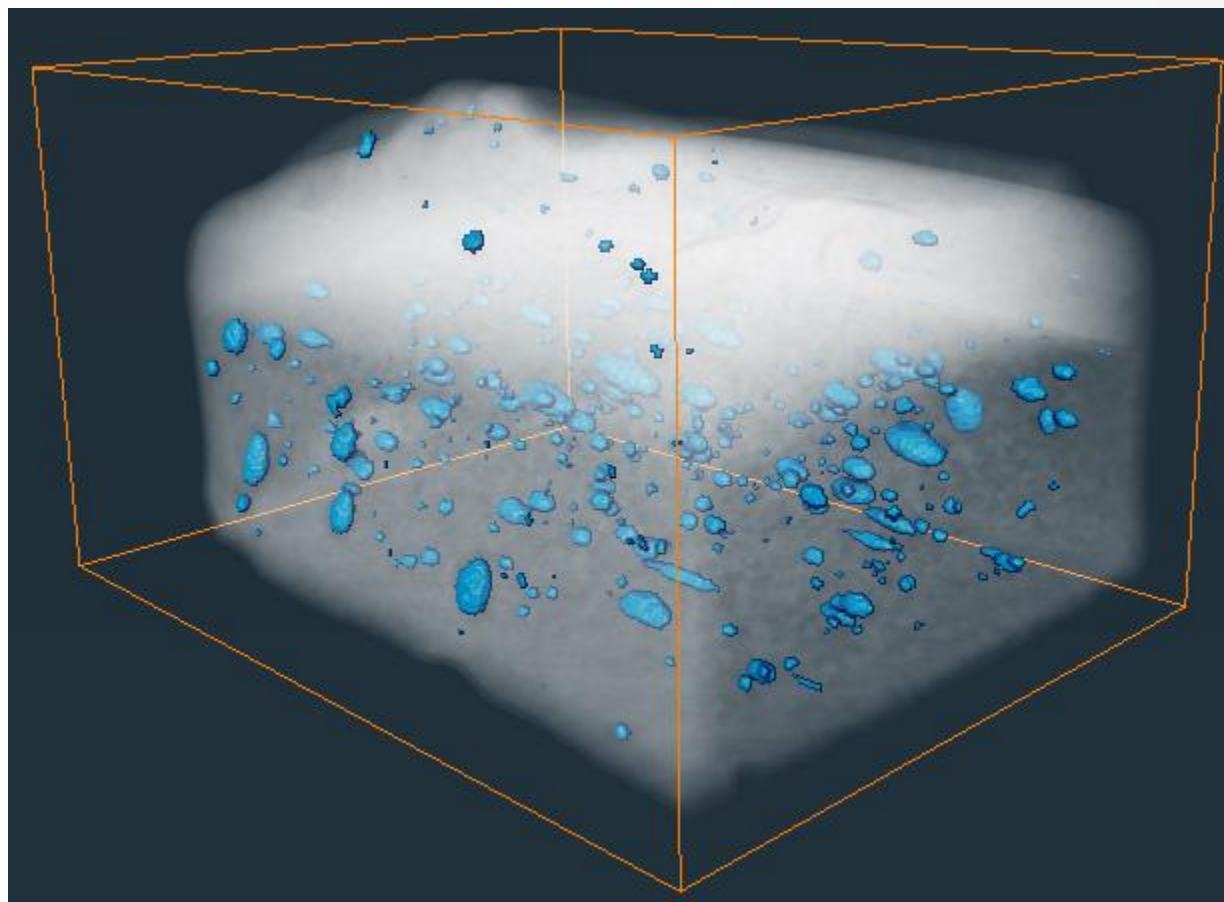
- Fill holes (slices only)
 - For 3D rather use Selection > Fill Holes
- Smooth Label:
 - 2D or 3D smoothing of the label map (shape only)
- Remove Islands:
 - Select small connected components
 - Relabel them according to the dominant neighboring label



Segmentation Editor: exercise 1

Bubble segmentation

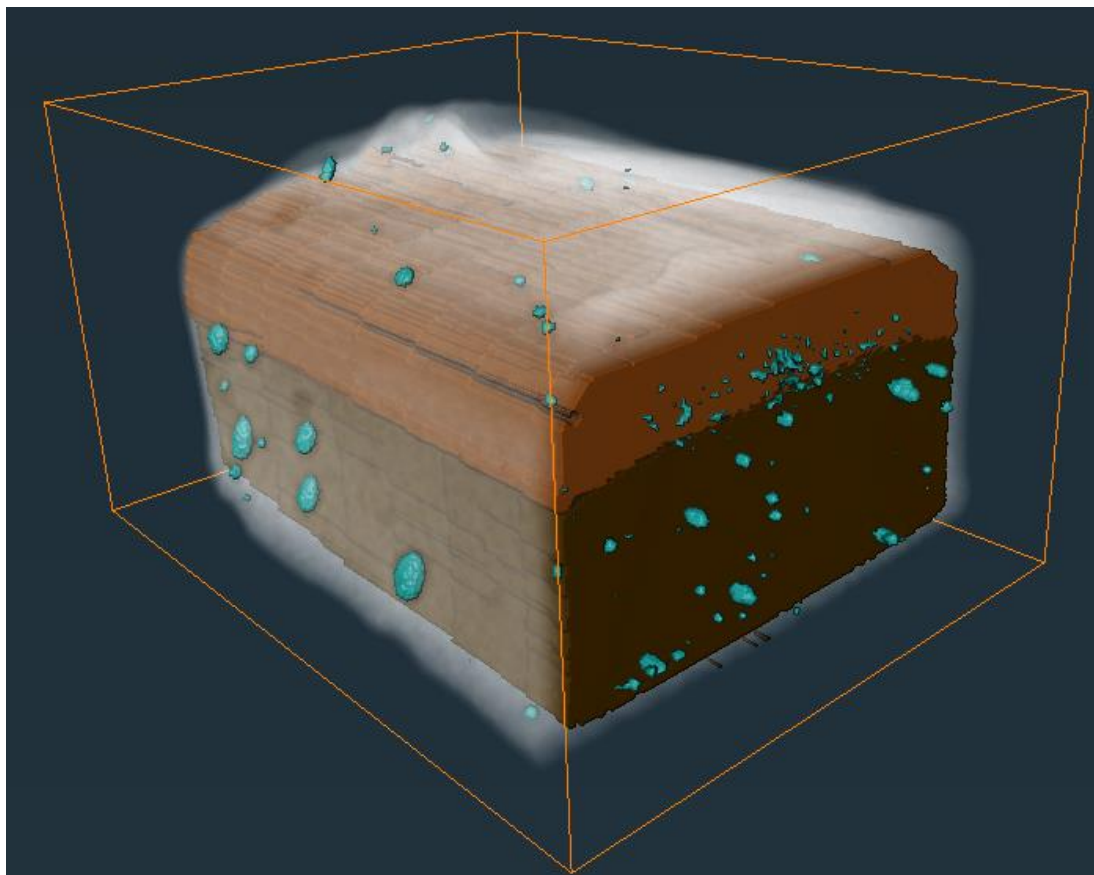
Use “**Thresholding**” and “**Fill Selection**” to segment chocolate bar and bubbles:



Segmentation Editor: exercise 2

Caramel and biscuit segmentation

- Use “**Brush**” or “**Blow**” tool and “**Interpolation**” to segment the chocolate mousse.
- Use “**Lasso**” tool and “**Interpolation**” to segment the caramel.



Tips:

- Segment the **denoised** image rather than the noisy one
- “**Blow**” tool and “**Lasso**” (Auto trace) are sensitive to the visualization range. Adjust the contrast accordingly.

Segmentation Editor: solution to exercises

Tutorial: <https://youtu.be/IQsKXRr9Njs>

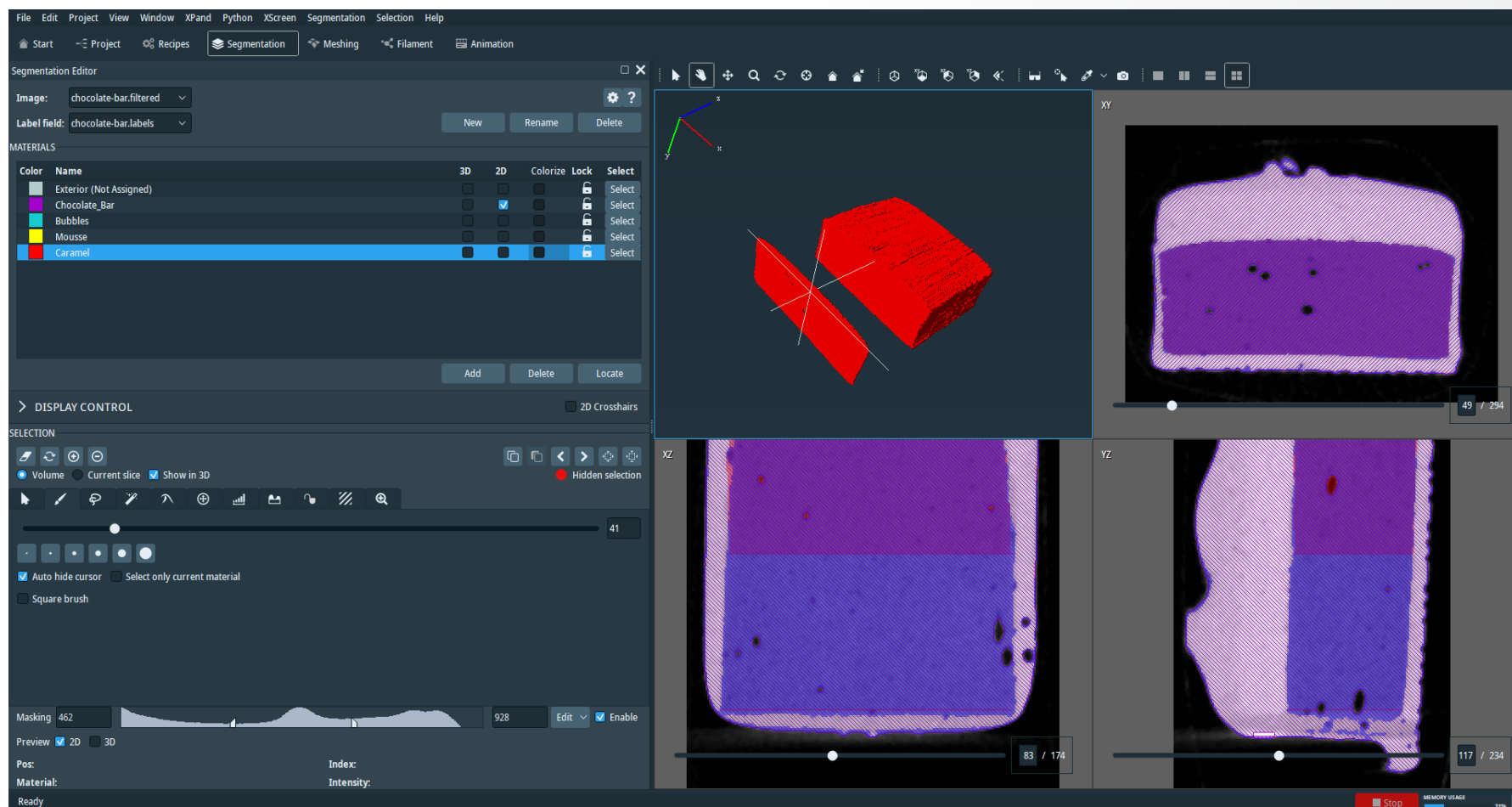
The screenshot displays the Segmentation Editor software interface. The main window shows a 3D visualization of a segmented chocolate bar, with the 'Caramel' layer highlighted in red. The interface includes a menu bar (File, Edit, Project, View, Window, XPand, Python, XScreen, Segmentation, Selection, Help) and a toolbar with various tools. The left sidebar contains the 'MATERIALS' list, a 'DISPLAY CONTROL' section, and a 'SELECTION' panel with various tools and settings. The right side of the interface features three 2D slice views: XY, XZ, and YZ, each with a corresponding slider and a 'Stop' button. The status bar at the bottom indicates 'Ready' and 'MEMORY USAGE 31%'.

Color	Name	3D	2D	Colorize	Lock	Select
Grey	Exterior (Not Assigned)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Purple	Chocolate_Bar	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Yellow	Bubbles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Green	Mousse	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Red	Caramel	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select

Segmentation Editor: solution to exercises

Tutorial: <https://youtu.be/IQsKXRr9Njs>

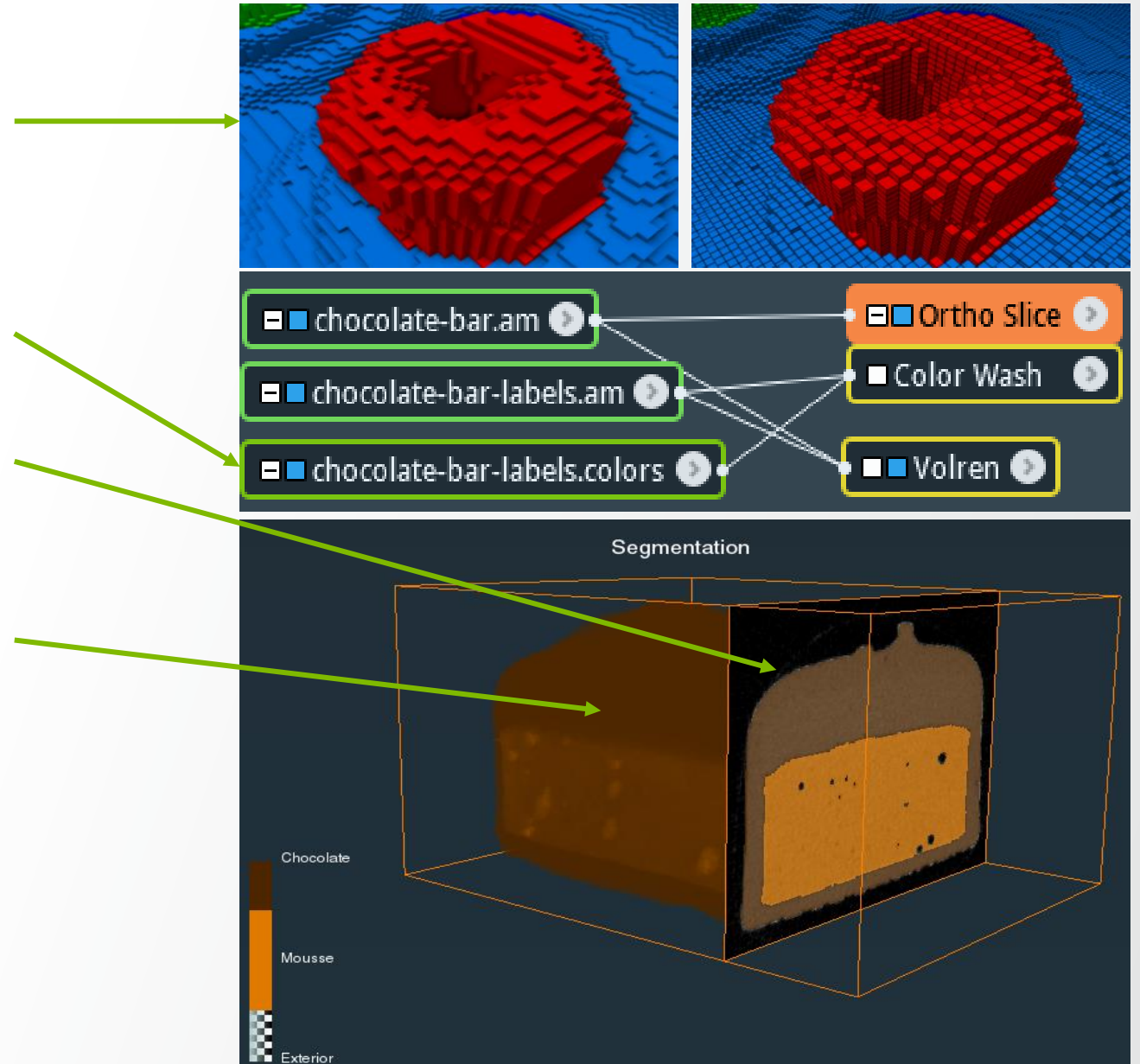
For setting the Viewer position as in the illustration, go to Edit-> Preferences->Segmentation->
ViewerLayout-3D Viewer Position: Upper Left



Visualization of segmentation maps

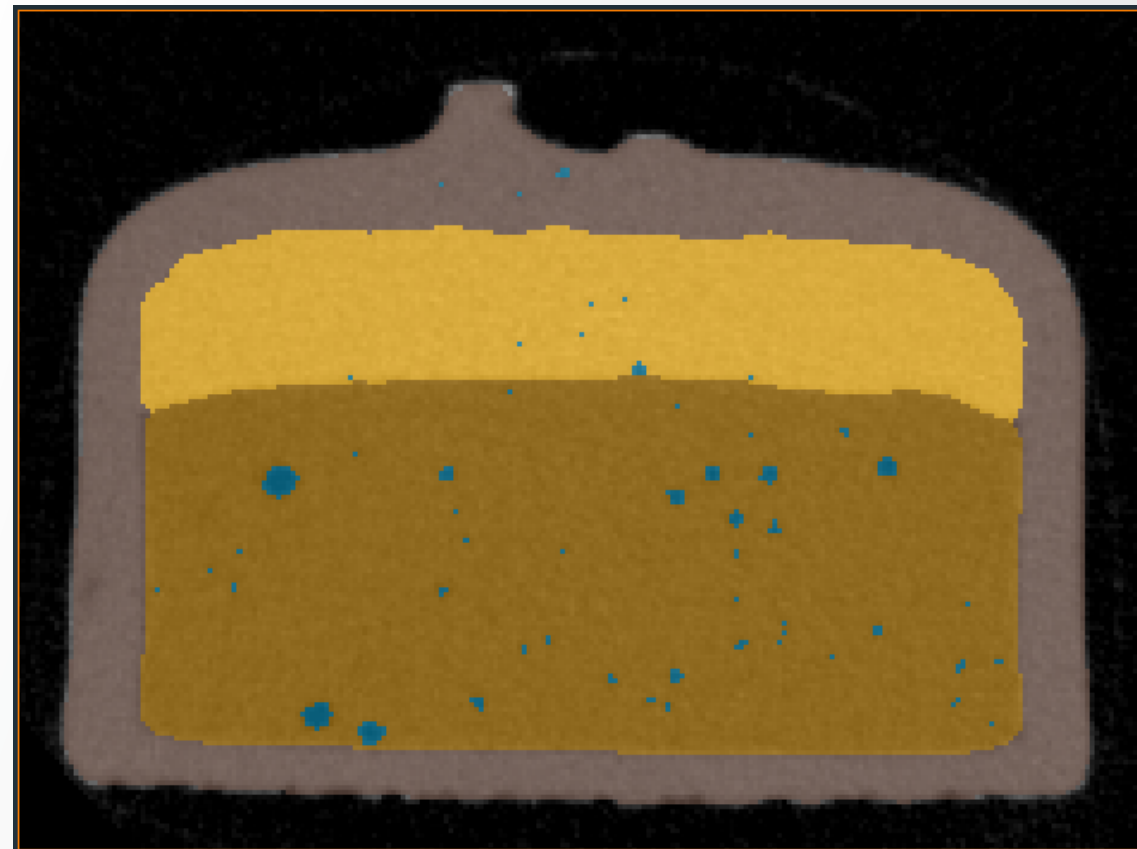
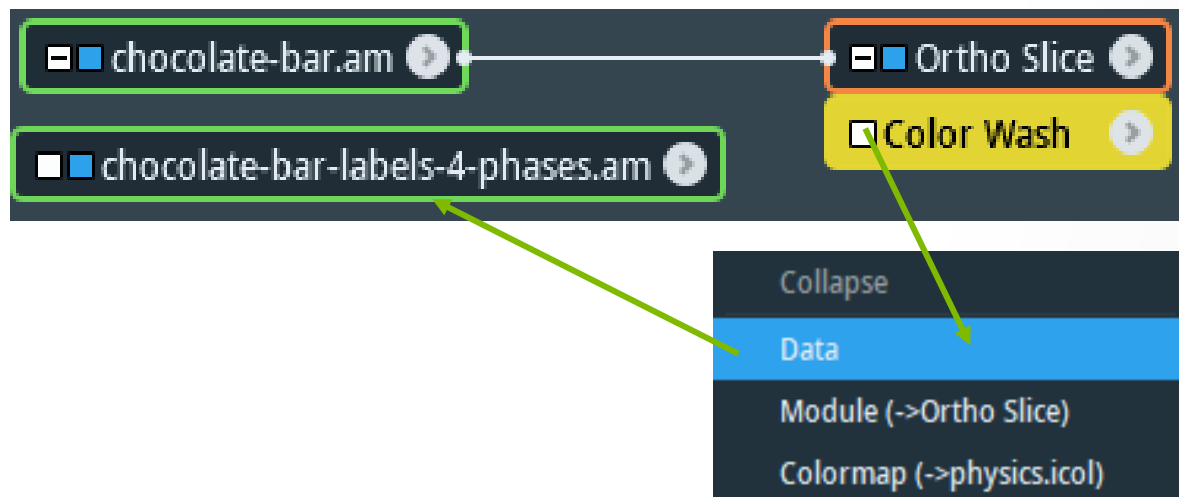
Visualization of segmentation maps: main modules

- **Voxelized Rendering:** displays the boundaries of voxels in a 3D volume,
- **Create Label Colormap:** Generates a label colormap with the colors defined in the Segmentation Editor
- **Colorwash:** details on next slide.
- **Volren:** displays 3d scalar fields volumes.
 - Connect a greyscale volume to 'Data' port, optionally a labeled image to port 'Labels'
 - Tune Transfer functions and materials.



Visualization of segmentation maps: Color Wash

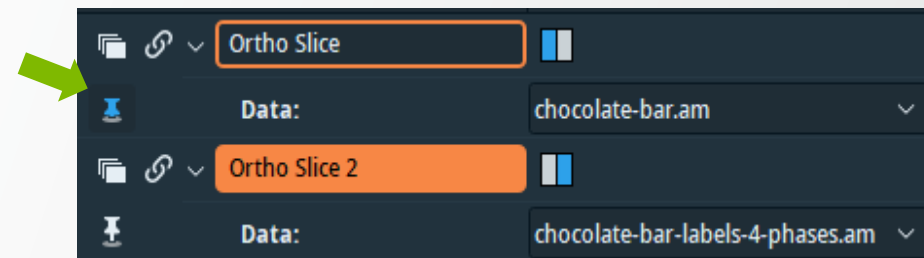
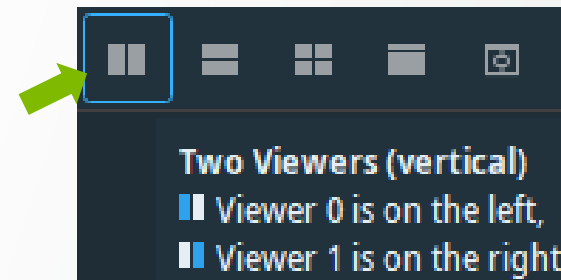
- Configure an **Orthoslice** to visualize the greyscale image
- Attach the **Colorwash** to **Orthoslice**
- Connect a label image to the port 'Data' of **Colorwash**
 - Adjust label transparency.



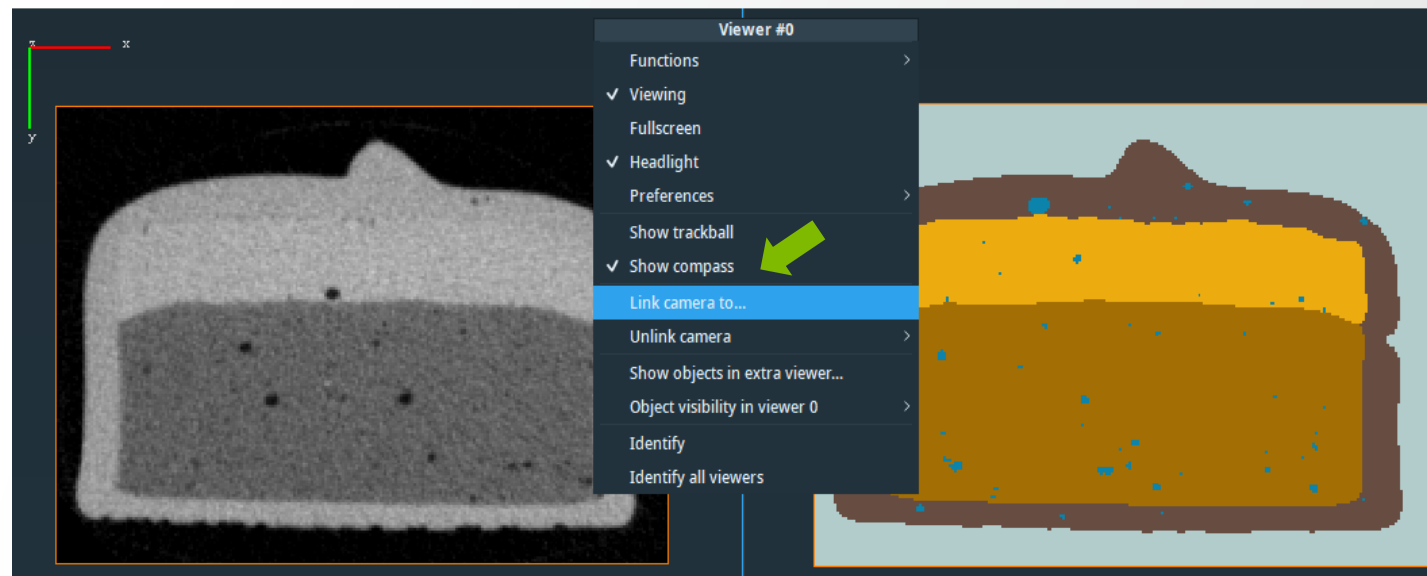
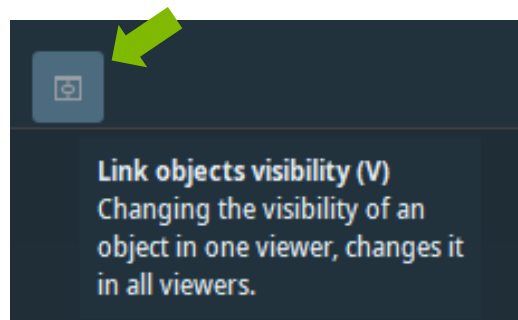
- **Colorwash** can also be connected to a grayscale image, various fusion rules are available

Visualization of segmentation maps: side by side viewers

- Attach **Ortho Slices** on 2 datasets
- Set 2 viewers and visibility of **Ortho Slices** on each viewer
Tip: pin “Data” port of one Ortho Slice to have it visible on both Ortho Slices
- Link cameras: right click in a viewer, link camera to...
left click on 2nd viewer



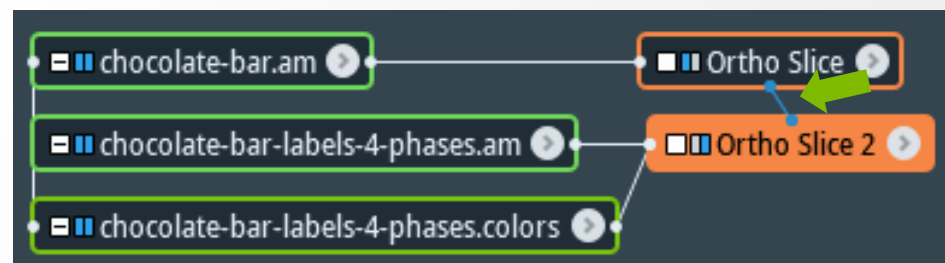
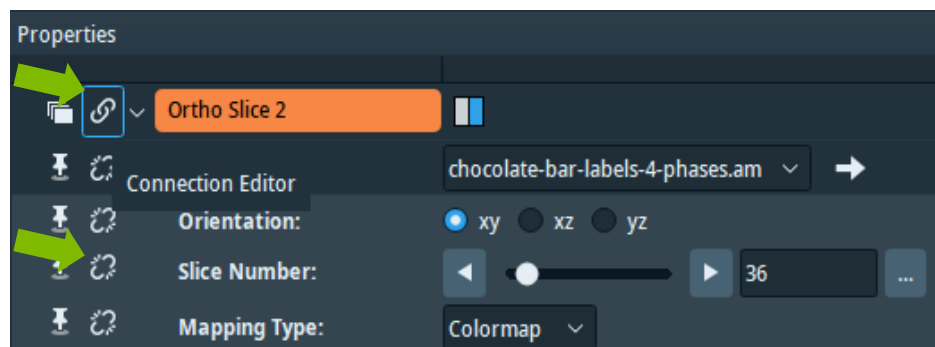
Tip: For independent viewers, make sure to switch off “**Link object visibility**”



Visualization of segmentation maps: linking ports

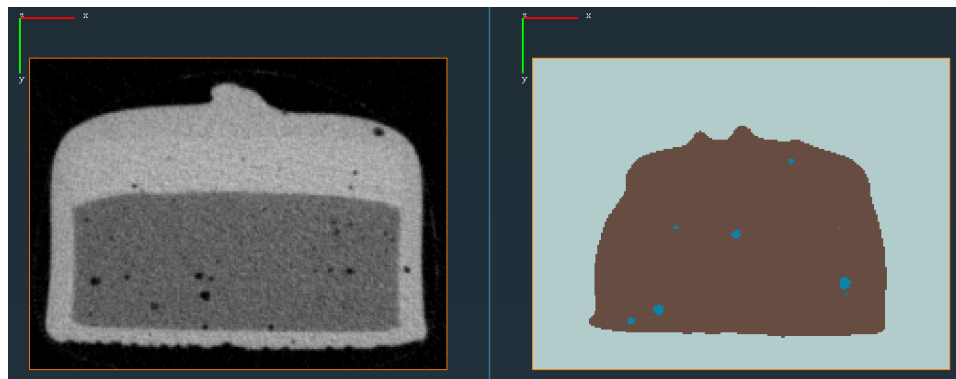
Linking ports – e.g. “Slice Number” port:

- Activate “Connection Editor” for “Ortho Slice 2”
- Click on the connection icon next to the port and drag over the “Ortho Slice” in the Project View



- Slice number ports are now linked, changing one will change the other simultaneously.

Before linking pots



After linking pots

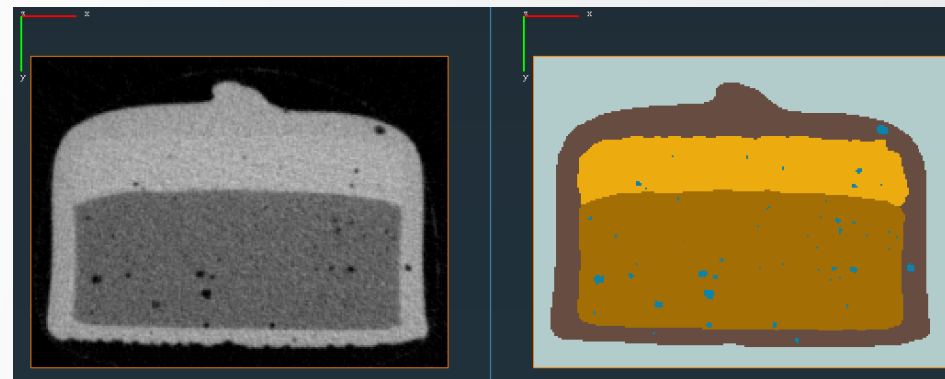


Image segmentation: general principles

Segmentation in image processing workflows

Step 1. Optimise image acquisition:

- Lower noise
- Improve contrast
- Remove artefacts

Step 2. Image pre-processing:

- Noise reduction filters
- Background correction
- Deconvolution

Step 3. Segmentation:

- Thresholding
- Mathematical morphology
- Watershed

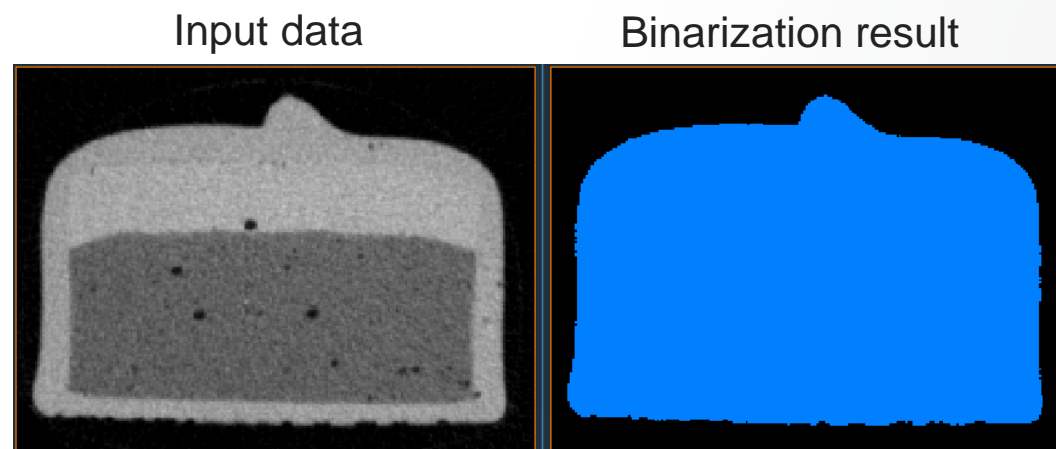
Step 4. Post-processing:

- Separate objects
- Clean segmentation maps

Image segmentation: concepts

Thresholding:

- **Binarization**: separating the dataset pixels/voxels into object and background.



- **Multi-thresholding**: separating the dataset pixels/voxels into several groups.

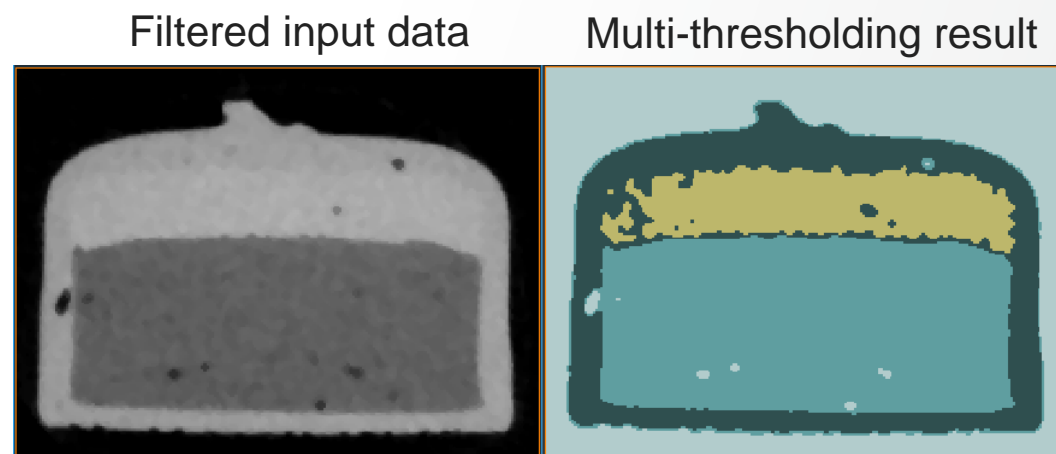


Image segmentation: thresholding methods

Main modules for performing thresholding:

- **Interactive** modules:
 - Interactive Thresholding
 - Used for binarization, allows setting the threshold value interactively
 - Multi-Thresholding
 - Up to five different regions separated by four different thresholds can be extracted
 - All thresholds are set interactively
- **Automatic** modules:
 - Auto Thresholding
 - Binary or 3-phase segmentation
 - The threshold or (thresholds for 3-phase mode) are computed automatically
 - 4 methods available for threshold computation
- **Local thresholding** modules:
 - Local Thresholding
 - Adaptive Thresholding

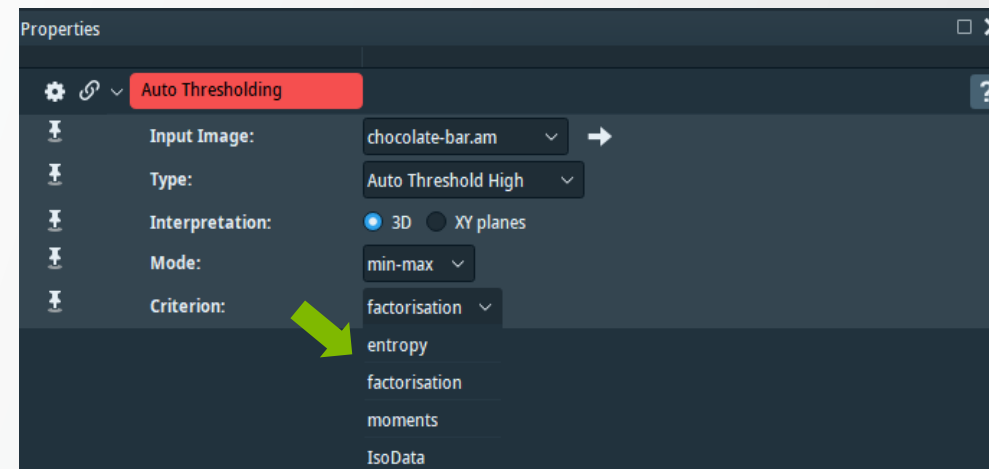


Image segmentation: thresholding methods example

Multi-thresholding:

- Use **Multi-Thresholding** module:
 - For setting segmentation **regions**: write a name for each segmentation region
 - For setting **threshold values**: study the histogram – place thresholds between histogram lobes
 - The intensity range between two threshold values defines a region
 - Push **Histo** button to generate the histogram

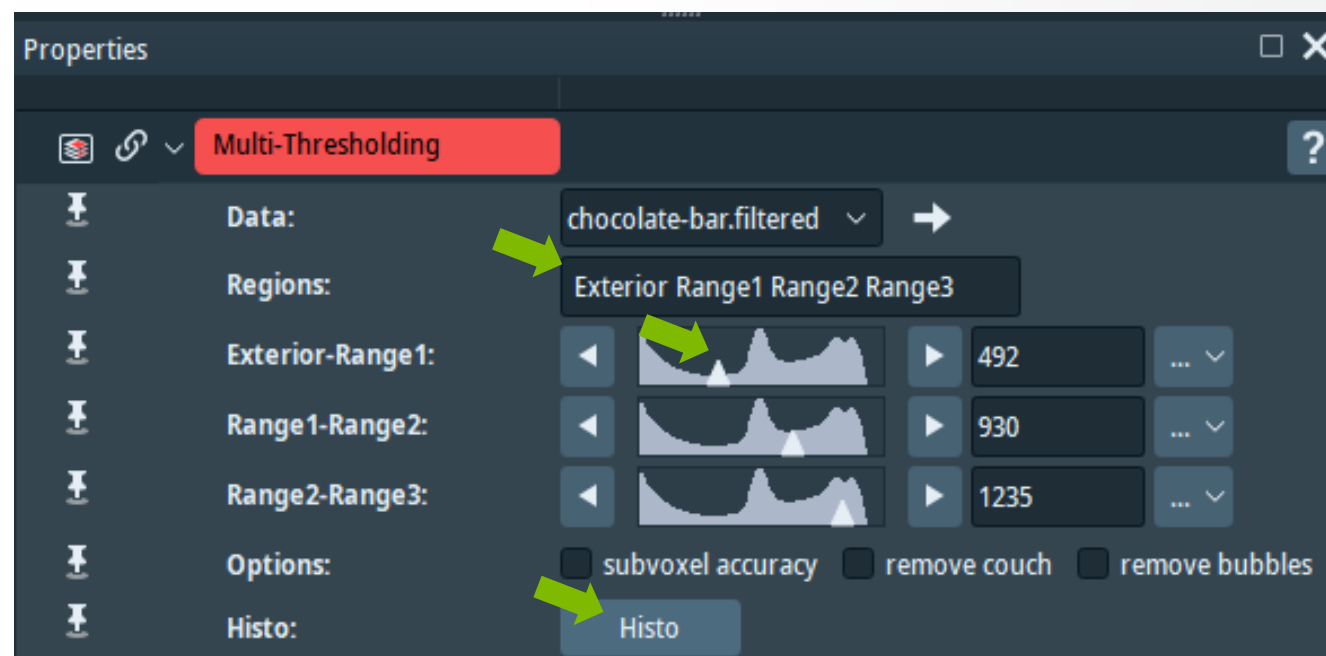
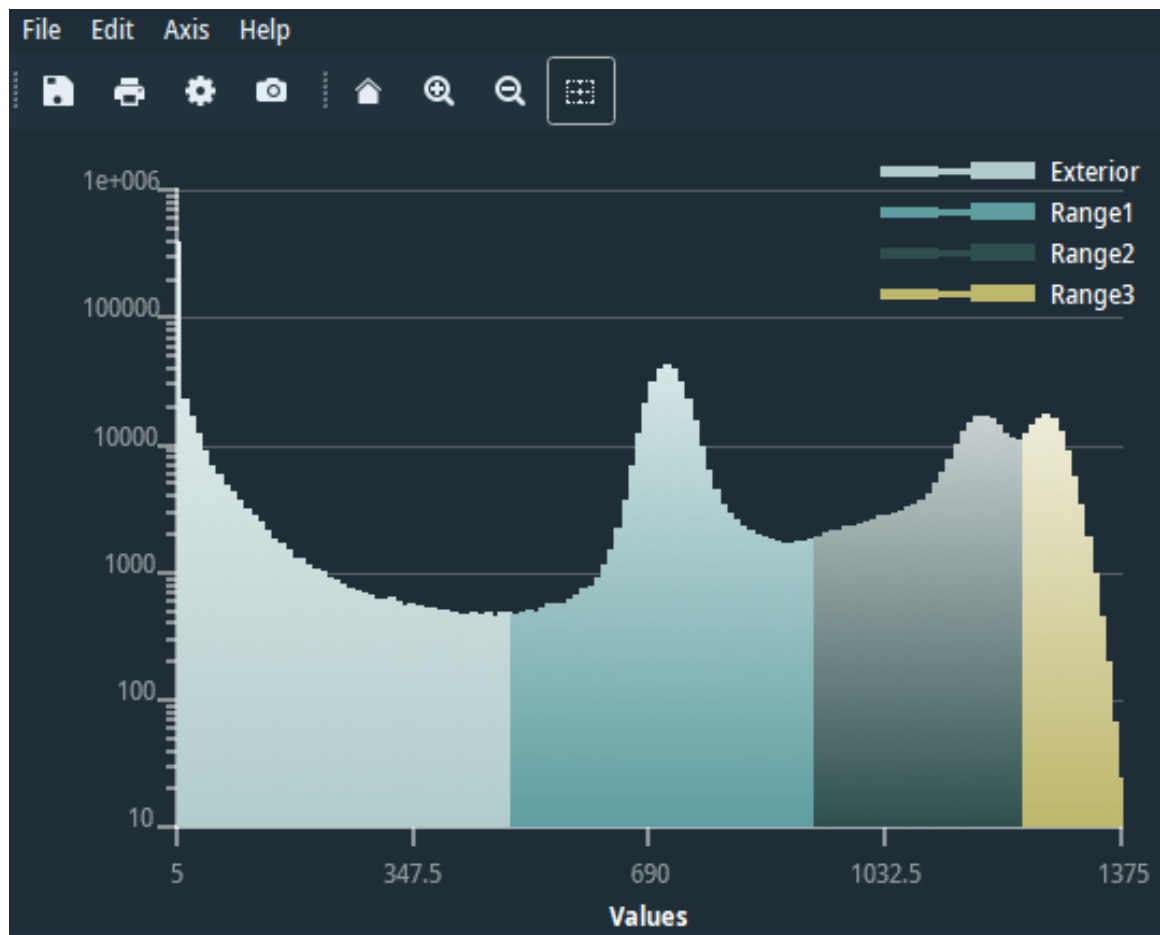


Image segmentation: thresholding methods example

Multi-thresholding:

Histogram



Multi-thresholding result

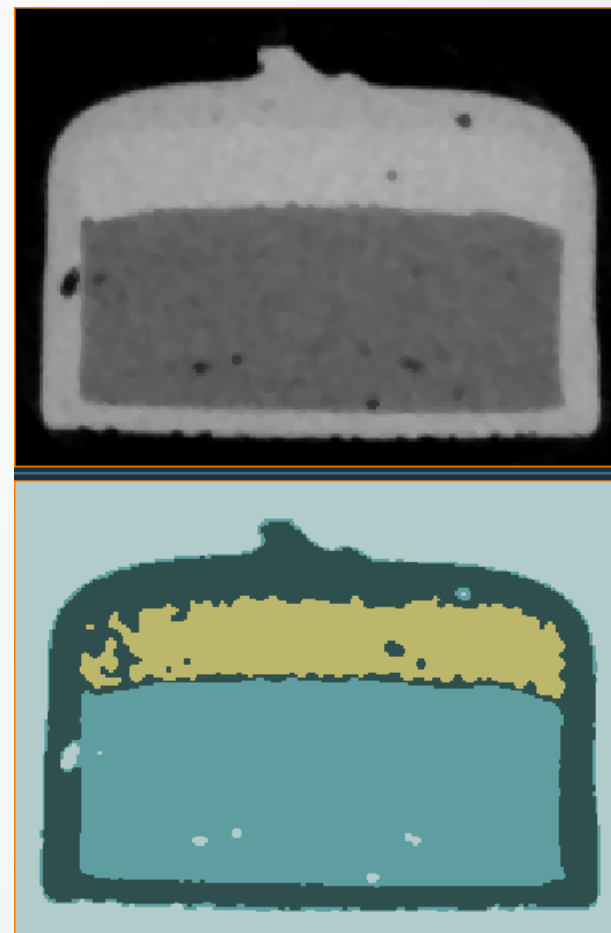
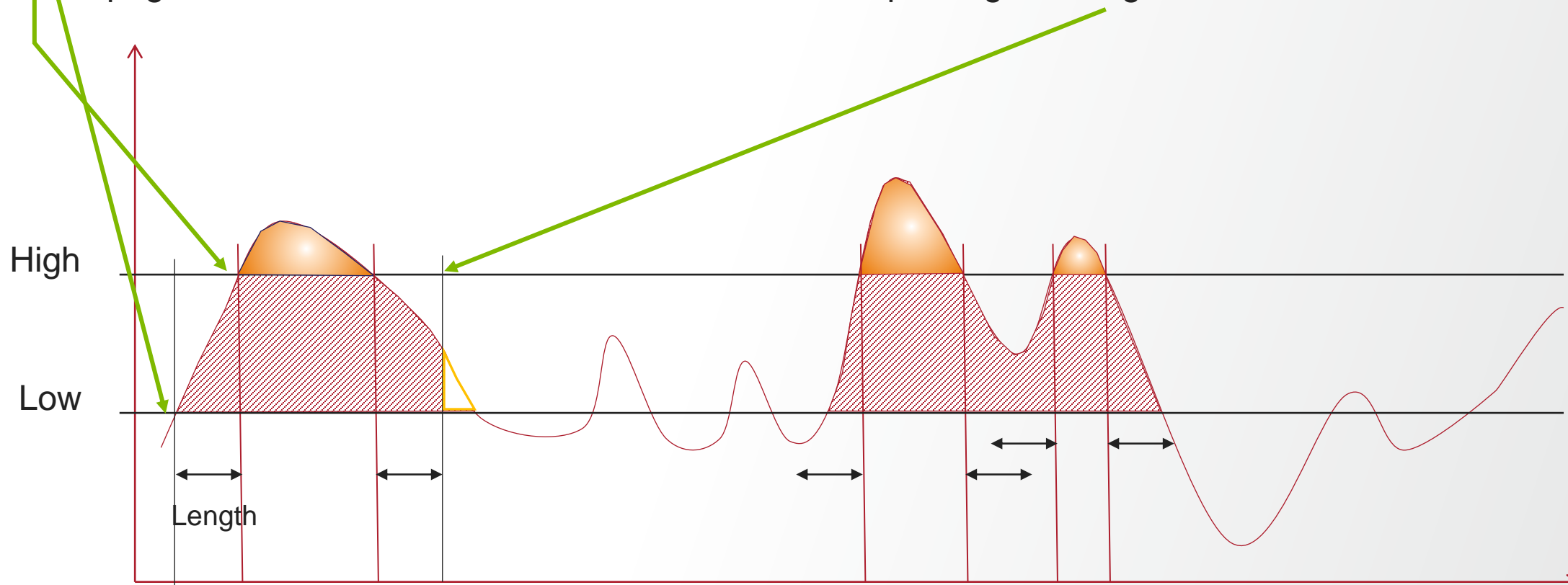


Image segmentation: thresholding advanced

Hysteresis thresholding

- Starts from regions selected with high threshold
- Propagates into voxels with intermediate intensities - up to a given length



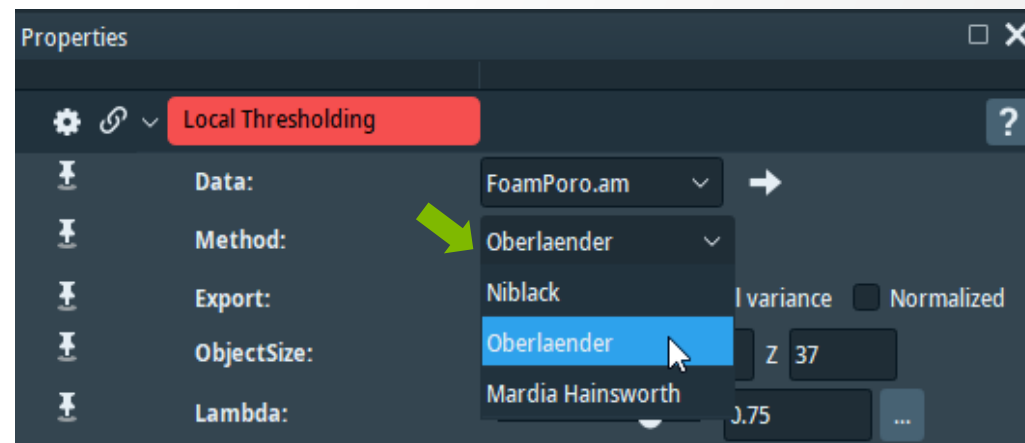
Tip: Use probes, or an interactive thresholding module to help set both threshold values

Image segmentation: thresholding methods example

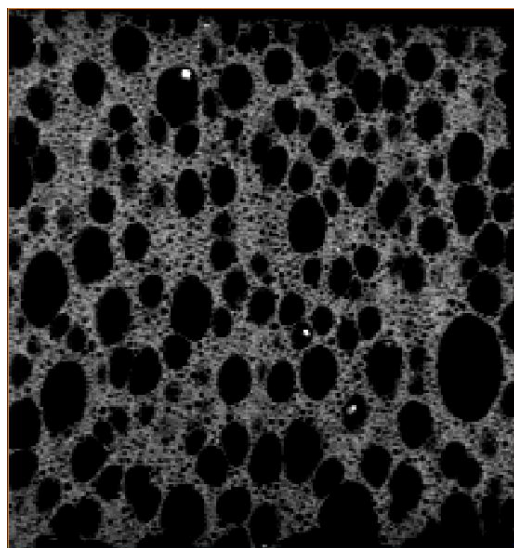
Local thresholding:

- Use **Local Thresholding** module:
 - For foreground object detection
 - For datasets presenting small background variations
- Three methods are available

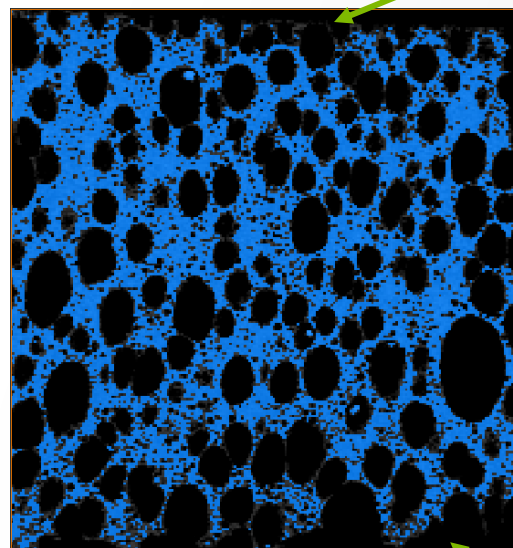
Example on *FoamPoro.am* dataset:



Input slice



Auto-thresholding result



Local-thresholding result

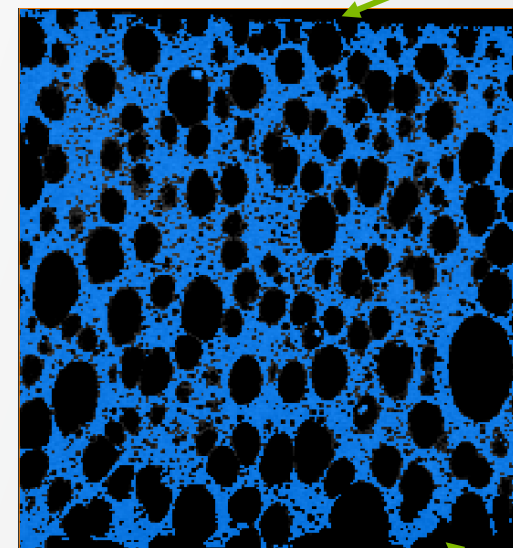
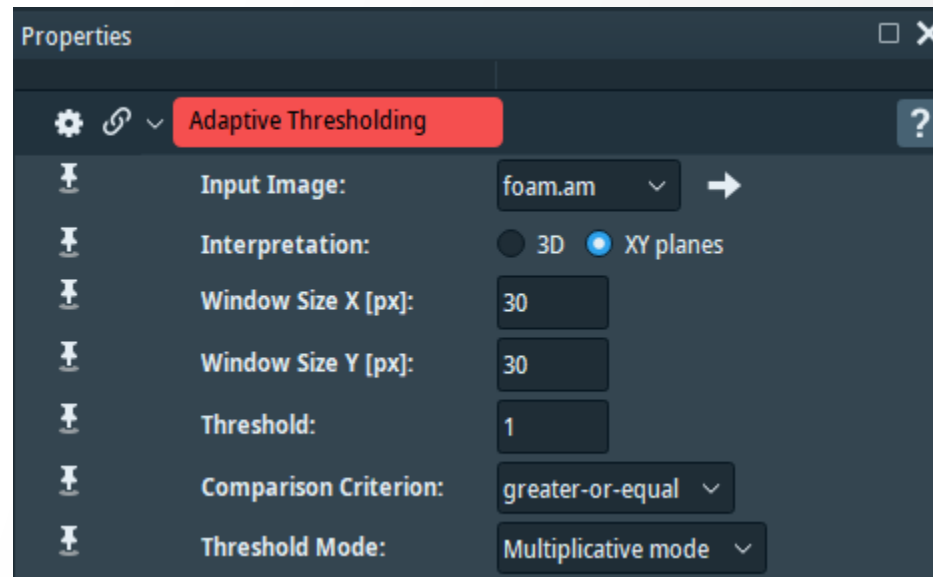


Image segmentation: thresholding methods example

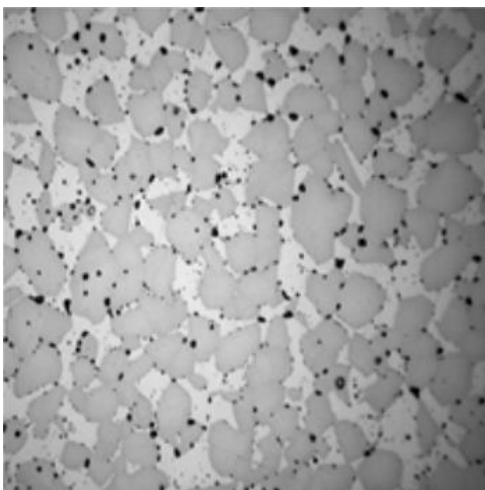
Adaptive-thresholding:

- Use **Adaptive-Thresholding** module:
 - For thresholding problems that require to adapt the threshold locally e.g. in the case of intensity variation along the data

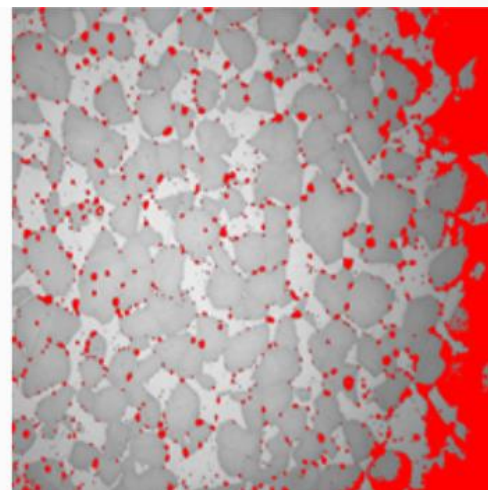
Example on **???** dataset:



Input slice



Global-thresholding result



Local-thresholding result

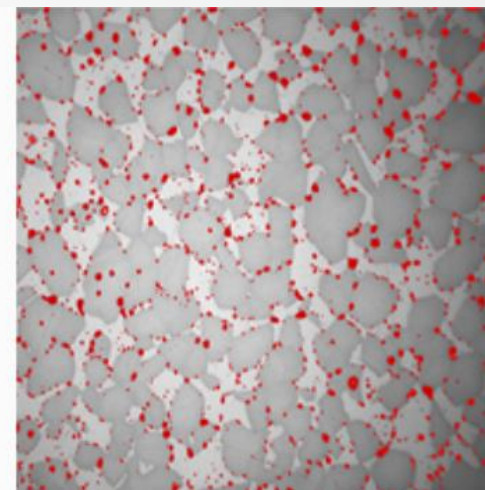


Image segmentation: thresholding methods limitations

Thresholding limitations (e.g. on Multi-thresholding):

- Segmentation artefacts at the boundary between regions (alternative: watershed)

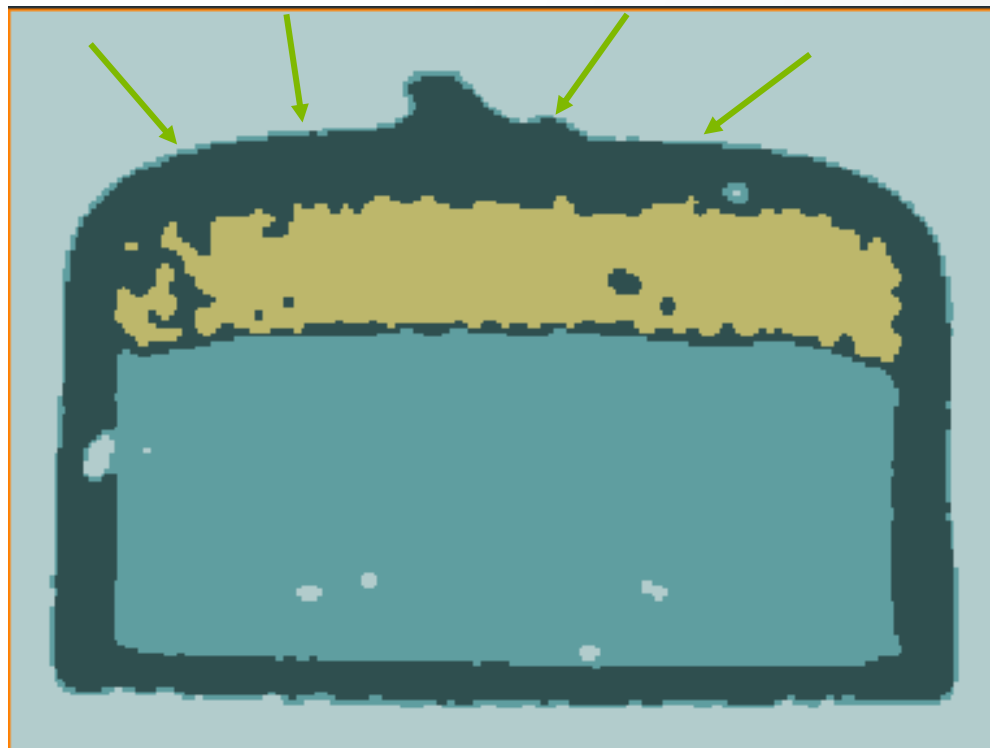


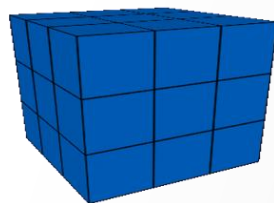
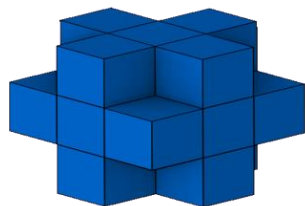
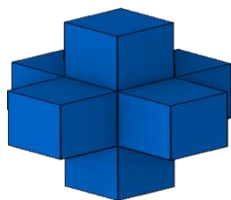
Image segmentation: advanced concepts

Part 1: mathematical morphology

Image segmentation: erosion and dilation - binary

Mathematical morphology (mm):

- **Structuring element** – neighborhood of voxels, defined by:
 - Size
 - Shape (cube, line, disk, ball)
 - Connectivity type – reminder for a cube neighborhood of size 1:



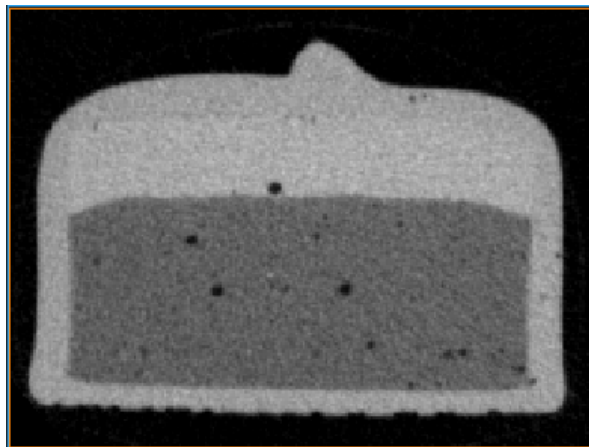
6 (common faces) 18 (common edges) 26 (common vertices)

- Basic mm operations:
 - **Erosion** – shrinks the object
 - If any voxel in the neighborhood is 0, the voxel is set to 0 in the eroded image, else to 1
 - **Dilation** – grows the object
 - If any voxel in the neighborhood is 1, the voxel is set to 1 in the dilated image, else to 0

Image segmentation: erosion and dilation – binary

Binary Erosion and Dilation exemple:

Input dataset



Binarized input



Erosion result



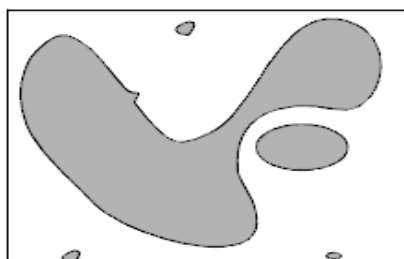
Dilation result



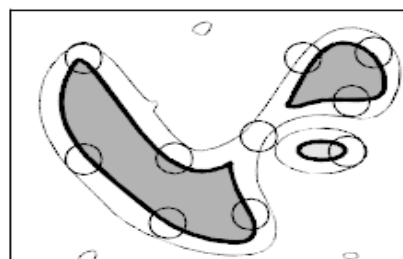
Image segmentation: erosion and dilation – grayscale

Erosion and Dilation on grayscale data:

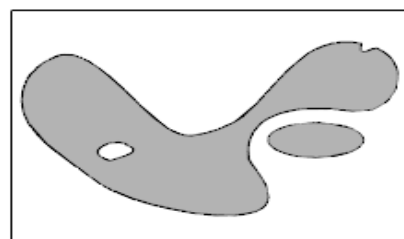
- **Erosion**
 - Replace voxel value by the minimum intensity value in neighborhood
 - Shrinks bright objects
- **Dilation**
 - Replace voxel value by the maximum intensity value in neighborhood
 - Expands bright objects



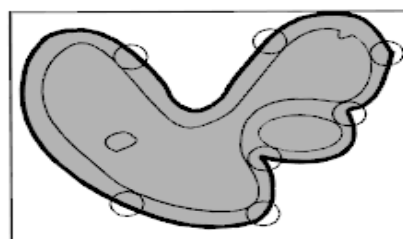
input image



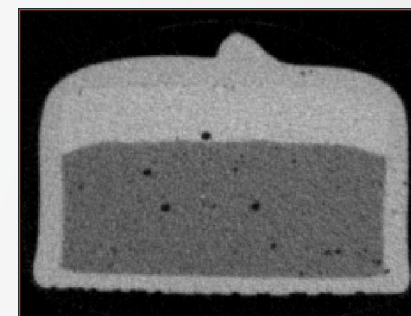
eroded image



input image



dilated image



Erosion result

Dilation result

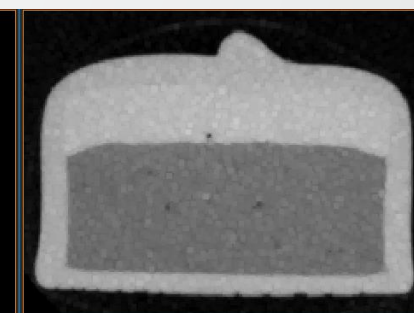
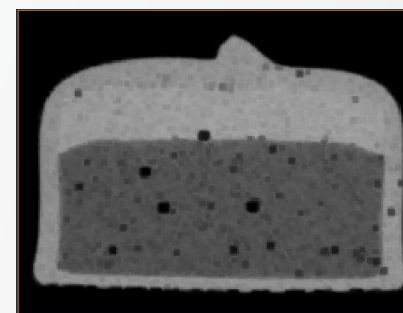
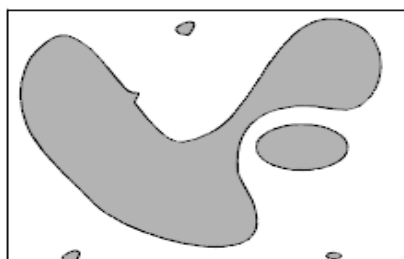


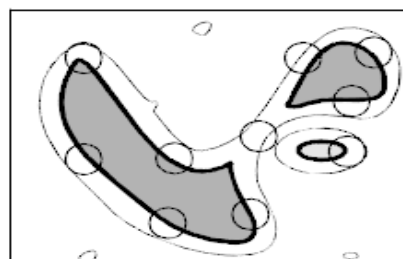
Image segmentation: erosion and dilation – grayscale

Erosion and Dilation on grayscale data:

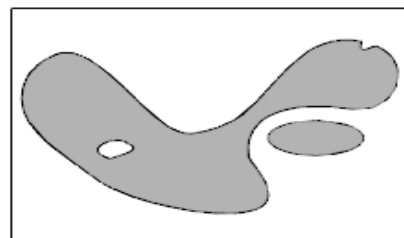
- **Erosion**
 - Replace voxel value by the minimum intensity value in neighborhood
 - Shrinks bright objects
- **Dilation**
 - Replace voxel value by the maximum intensity value in neighborhood
 - Expands bright objects



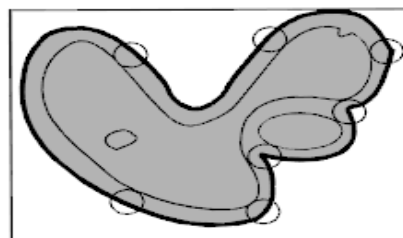
input image



eroded image

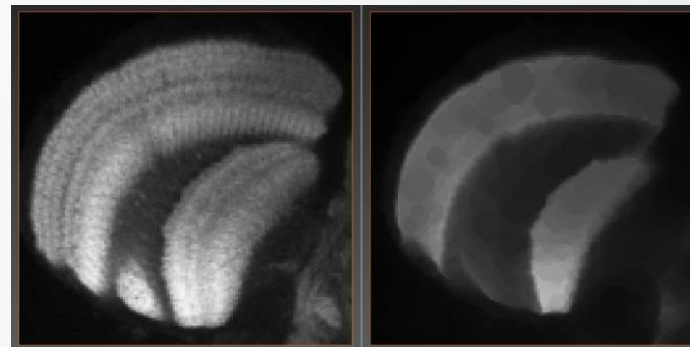


input image



dilated image

Erosion result



Dilation result

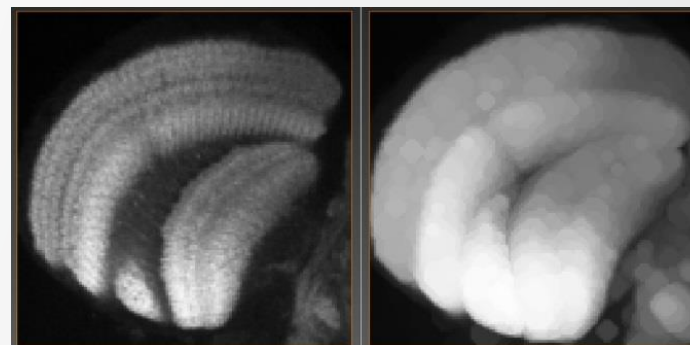


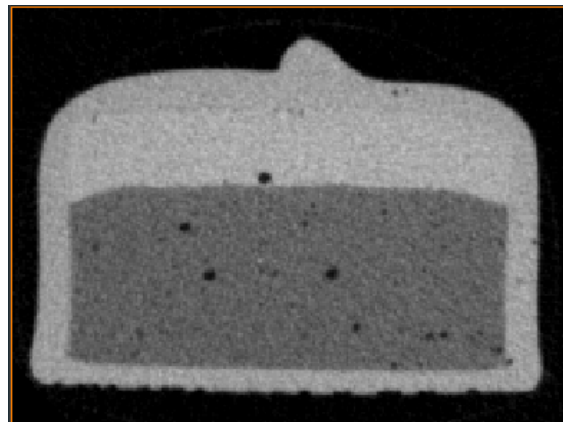
Image segmentation: opening and closing - binary

Mathematical morphology operations derived from Erosion and Dilation:

- **Opening:**
 - Erosion + Dilation
(using the same structuring element - SE)
 - All detection objects smaller than the size of the structuring element are removed
- **Closing:**
 - Dilation + Erosion
(using the same SE)
 - All void regions (label=0) smaller than the size of the structuring element are filled

Image segmentation: closing example - binary

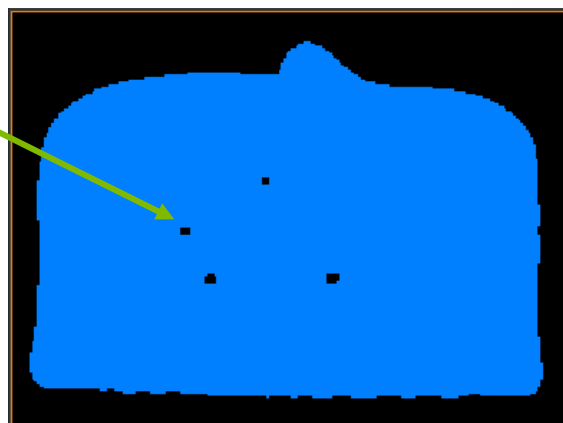
Input dataset



Thresholding result



Closing result
SE of size 1



Closing result
SE of size 3

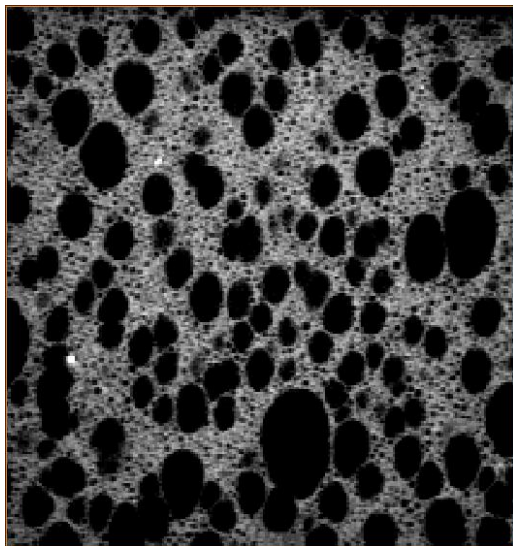


Note: the SE size is too small for filling all porosities.

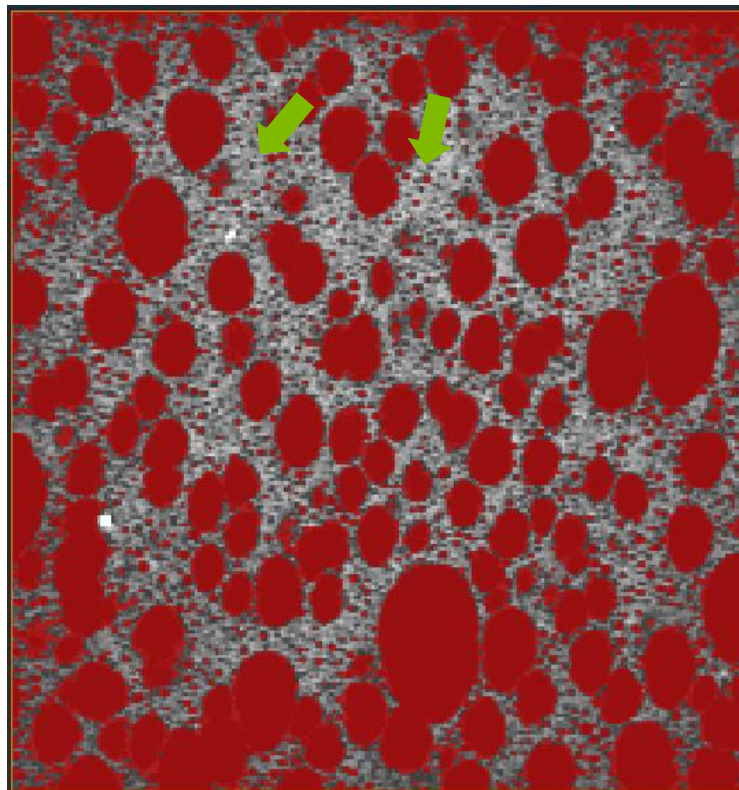
Closing: fills small holes (e.g. porosities) and connects detection objects that are close to each other.

Image segmentation: opening example - binary

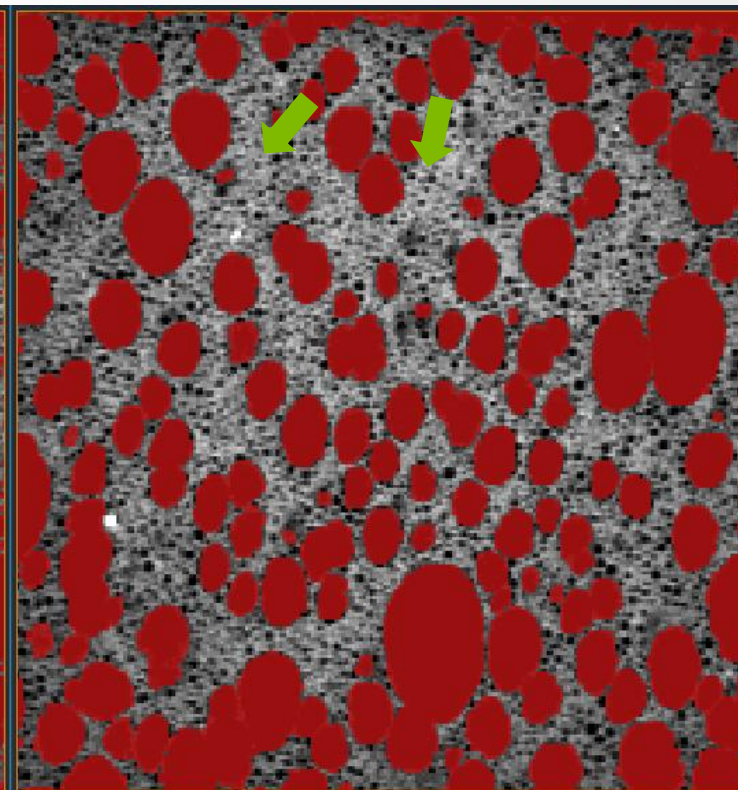
Input dataset



Thresholding result

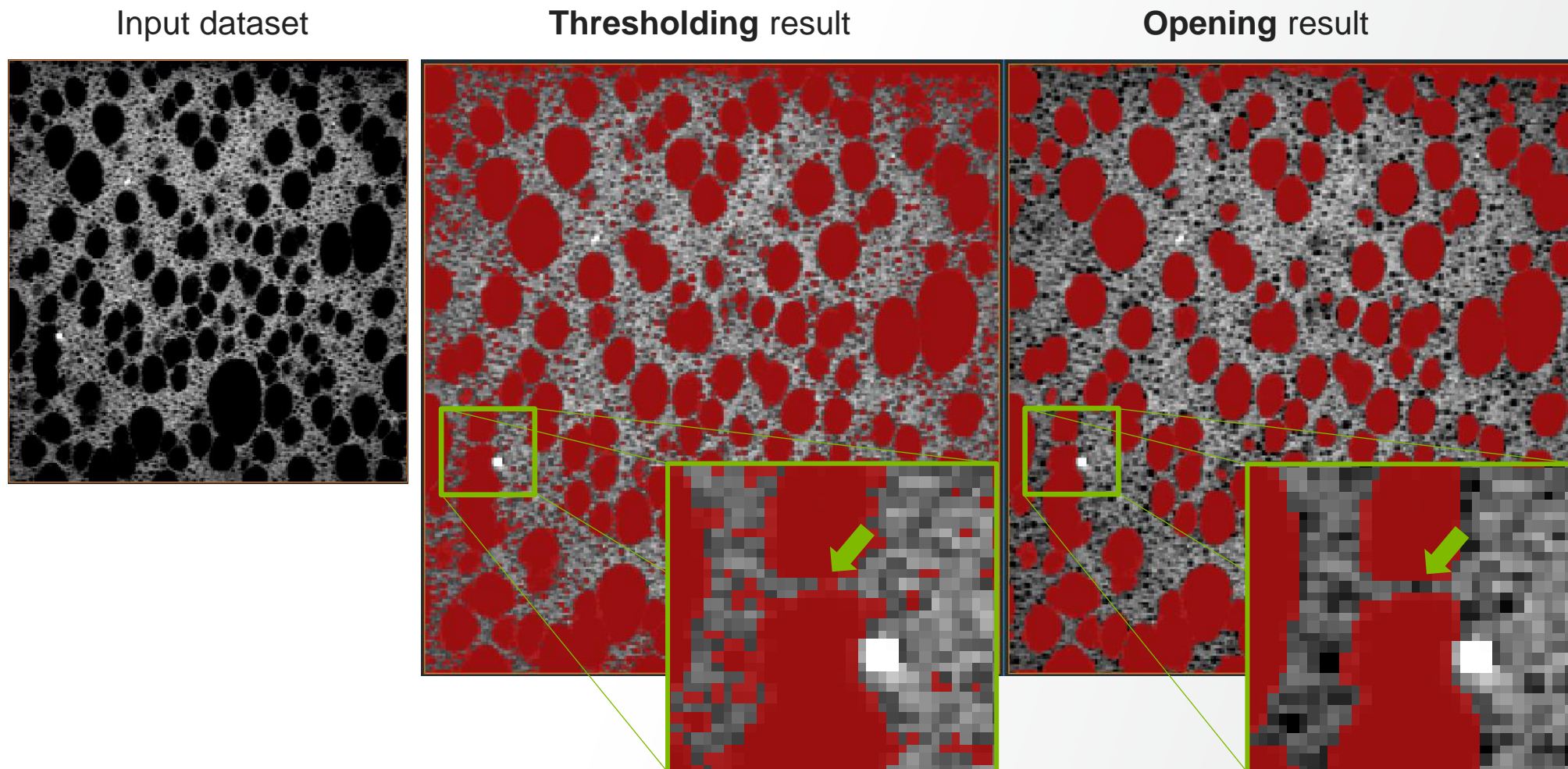


Opening result



Opening: removes small structures (clean segmentation results – remove artefacts of small size).

Image segmentation: opening example- binary

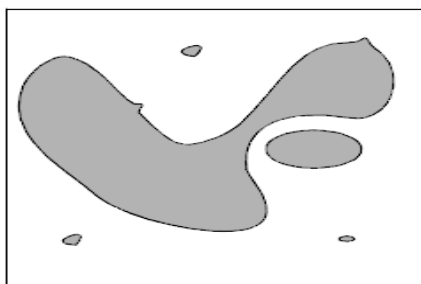


Opening: removes links (connections) of small size (e.g. separate detection object).

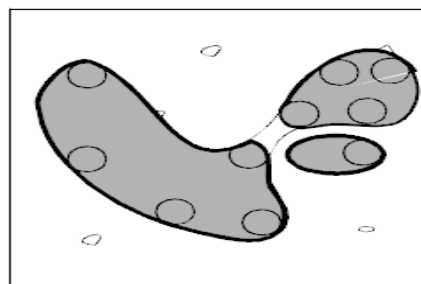
Image segmentation: opening and closing – grayscale

Opening and Closing on grayscale data:

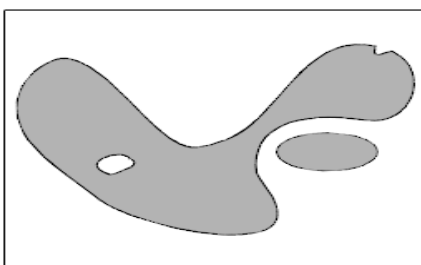
- **Opening**
 - Removes small bright structures.
- **Closing**
 - Removes small dark structures.



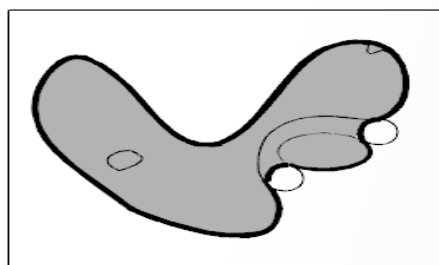
input image



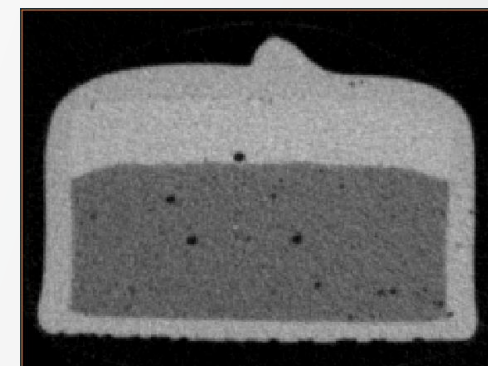
opened image



input image



closing



Opening result

Closing result

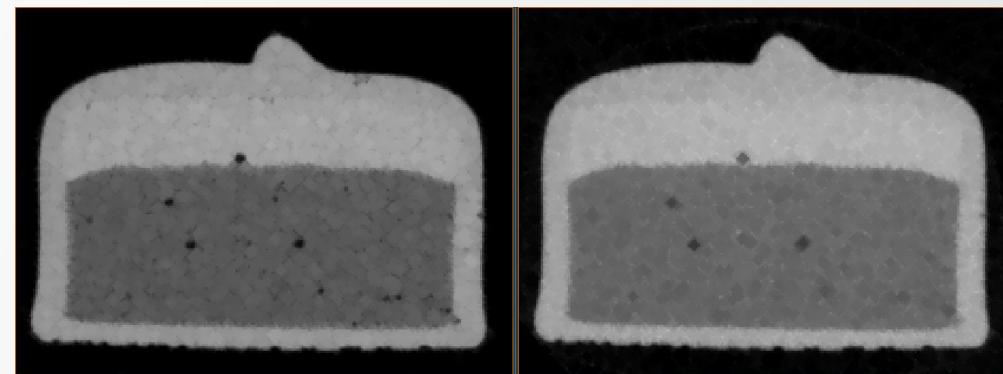
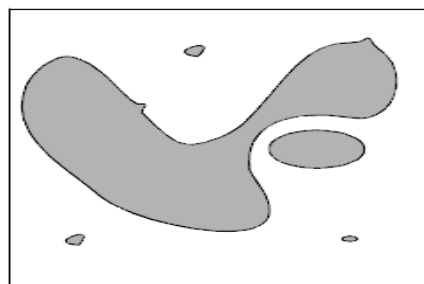


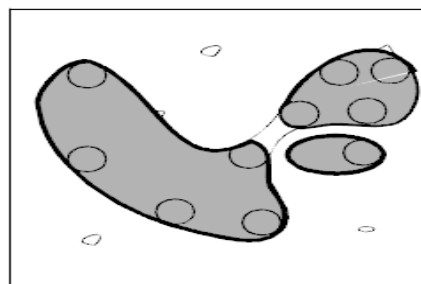
Image segmentation: opening and closing – grayscale

Opening and Closing on grayscale data:

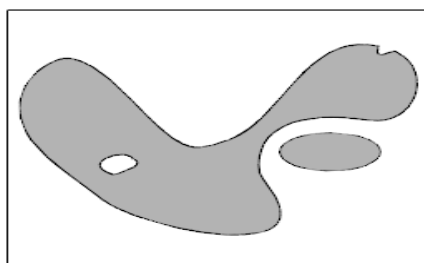
- **Opening**
 - Removes small bright structures.
- **Closing**
 - Removes small dark structures.



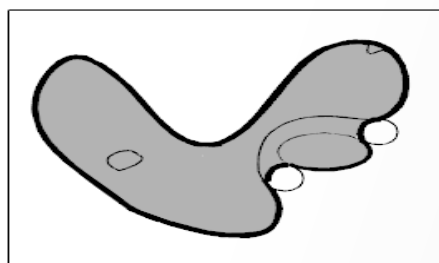
input image



opened image

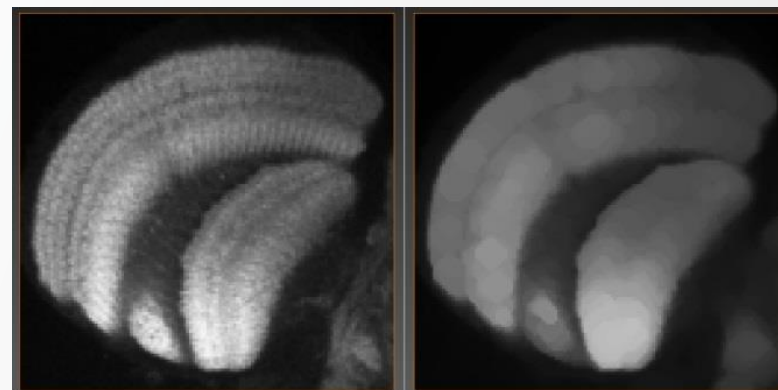


input image



closing

Opening result



Closing result

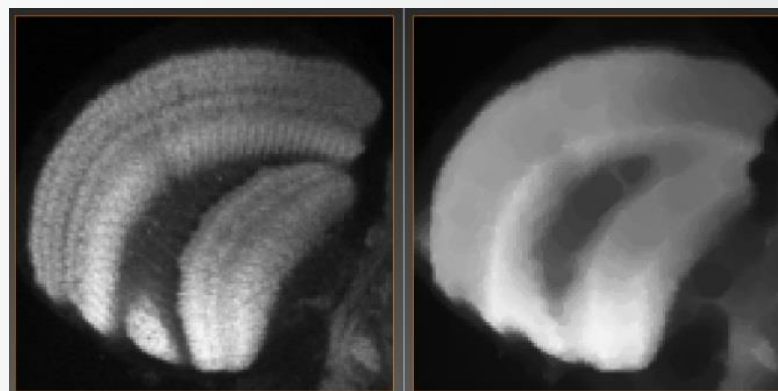


Image segmentation: when thresholding does not work

Q: How can we segment the small spots only ?

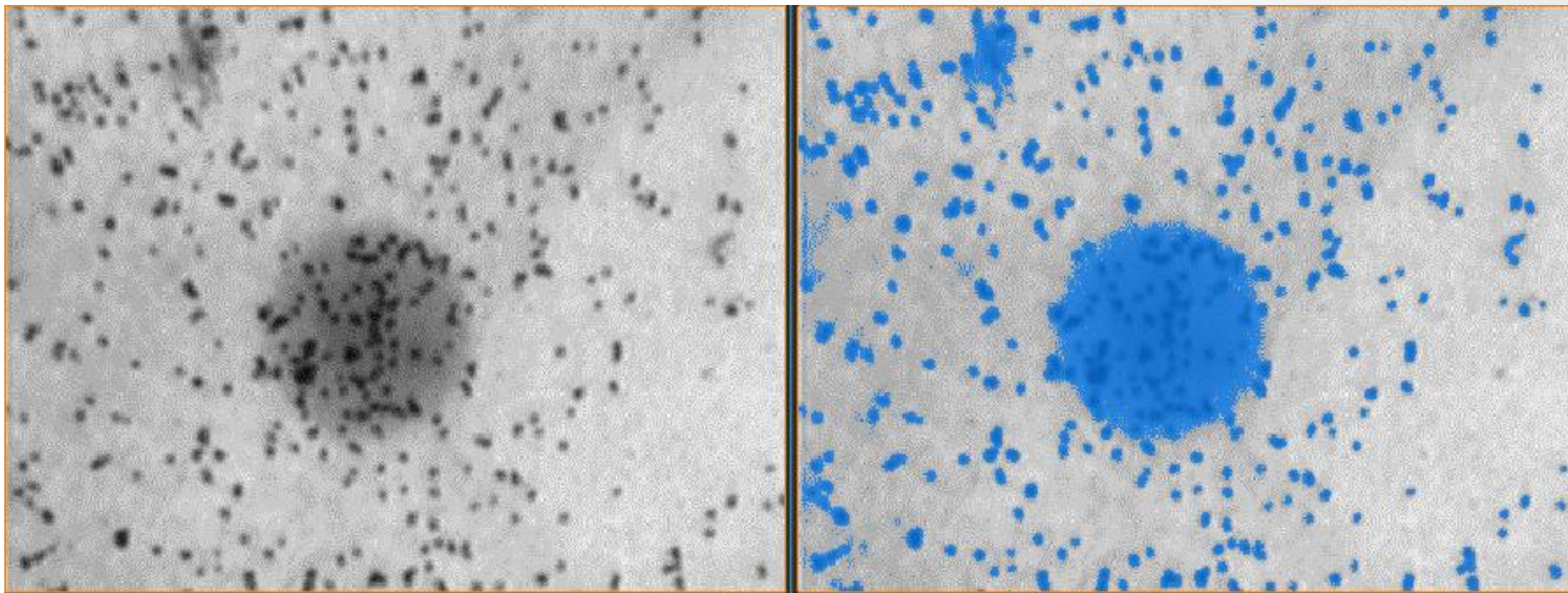


Image segmentation: Top-Hat Transform

R: Apply Top-Hat transform and then thresholding

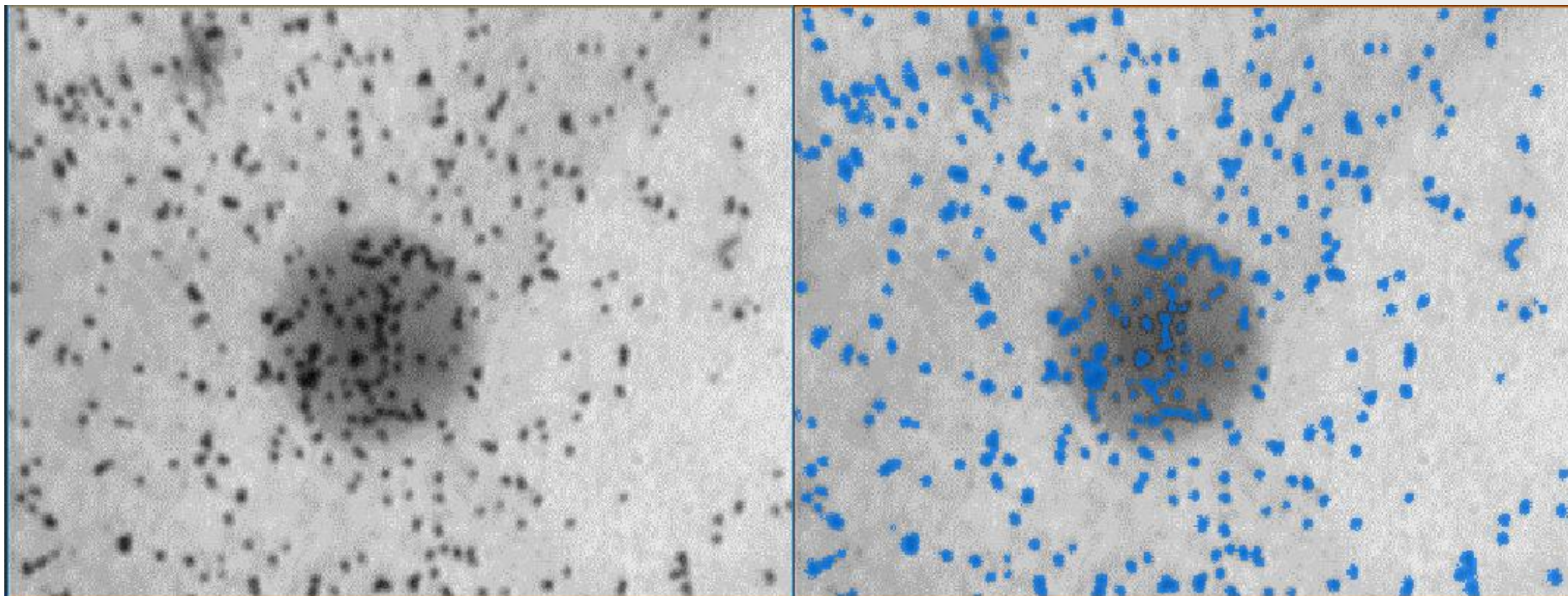


Image segmentation: Top-Hat Transform

Top-Hat (TH) Transform:

- Derived from Opening and Closing
- Highlights **small** size **structures**
- Two types of TH transform:
 - **White TH:**
 - Highlights bright structures
 - Mathematical expression: $\text{Input Data} - \text{Opening result}$
 - **Black TH:**
 - Highlights dark structures
 - Mathematical expression: $\text{Closing result} - \text{input data}$
- Good practice: apply before thresholding in order to corrects **non-uniform lighting**

Image segmentation: Top-Hat Transform example

Q: How does one get from A to B

A

B

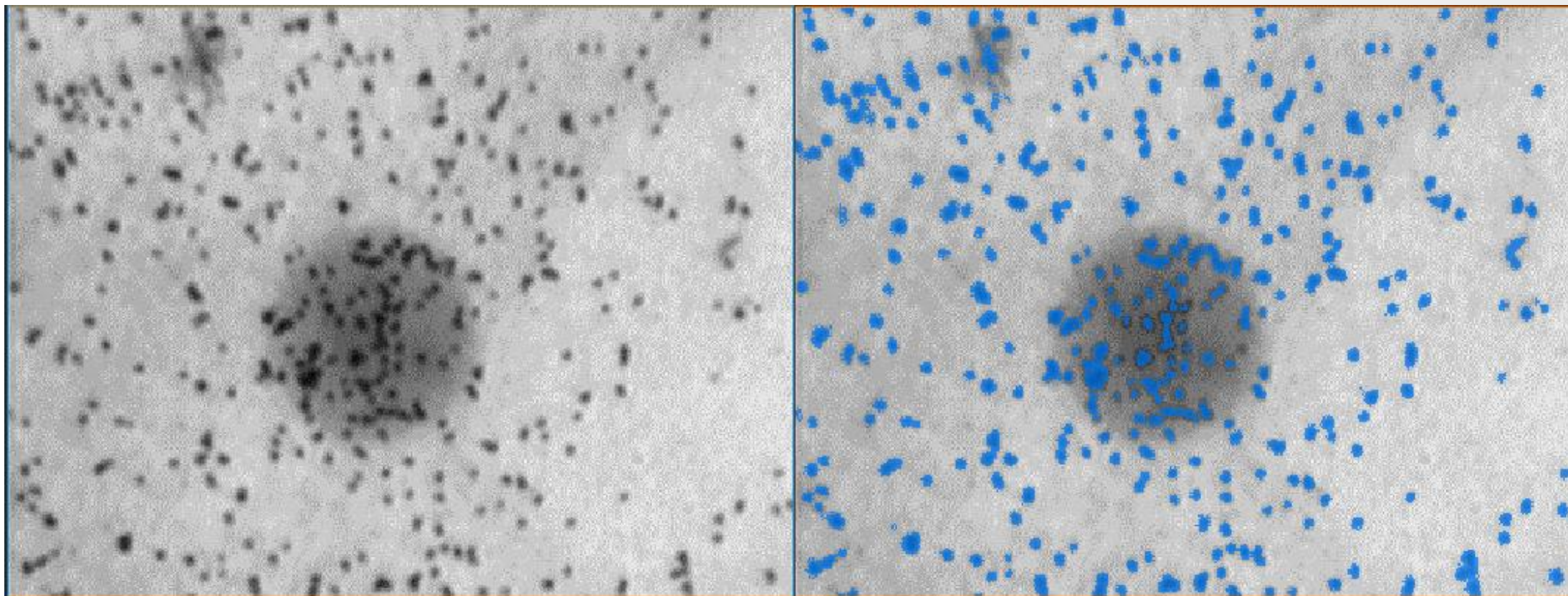


Image segmentation: Top-Hat Transform example



Getting from A to B:

- Apply Closing to the Input
- Subtract Input from Closing Result → TH transform image
- Apply thresholding on the TH transform image
- Overlay result on Input (Colorwash)

Image segmentation: Top-Hat in Avizo

Ways of applying (TH) Transform in Avizo:

- Dedicated module
 - Interactive Top-Hat
- Use the modules that correspond to the operations composing the TH transform
 - Opening, Closing, Arithmetic/Subtract Image
 - Advantage – more flexibility in the choice of the:
 - Structuring element
 - Thresholding method
- Segmentation Editor:
 - Top-hat selection tool
 - TH transform image computation
 - Thresholding on the TH transform image

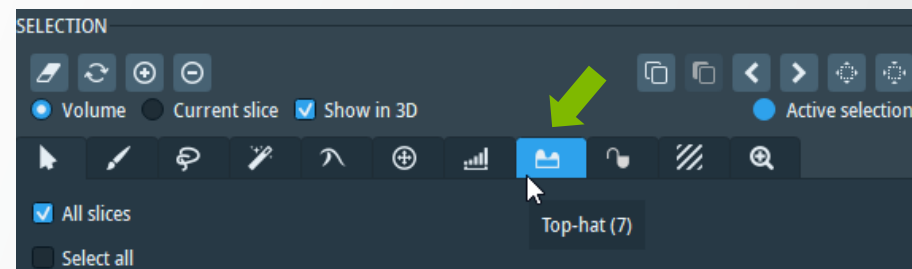
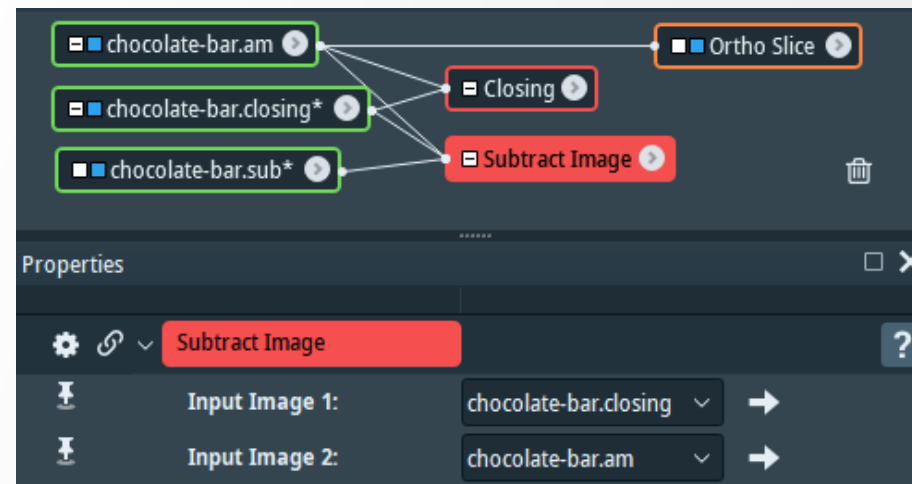
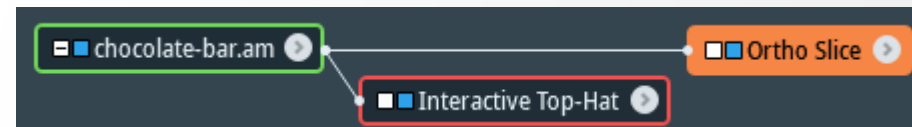


Image segmentation: Top-Hat in Amira

Ways of applying (TH) Transform in Amira:

- Dedicated module
 - Interactive Top-Hat
- Use the modules that correspond to the decomposed TH transform
 - Opening, Closing, Arithmetic/Subtract
 - Advantage – more flexibility in the choice of the:
 - Structuring element
 - Thresholding method
- Segmentation Editor:
 - Top-hat selection tool
 - TH transform image computation
 - Thresholding on the TH transform image

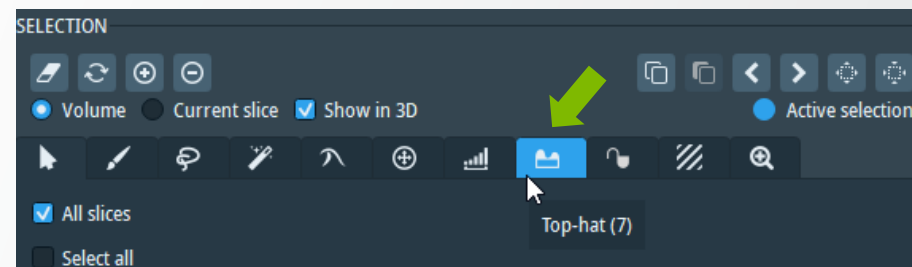
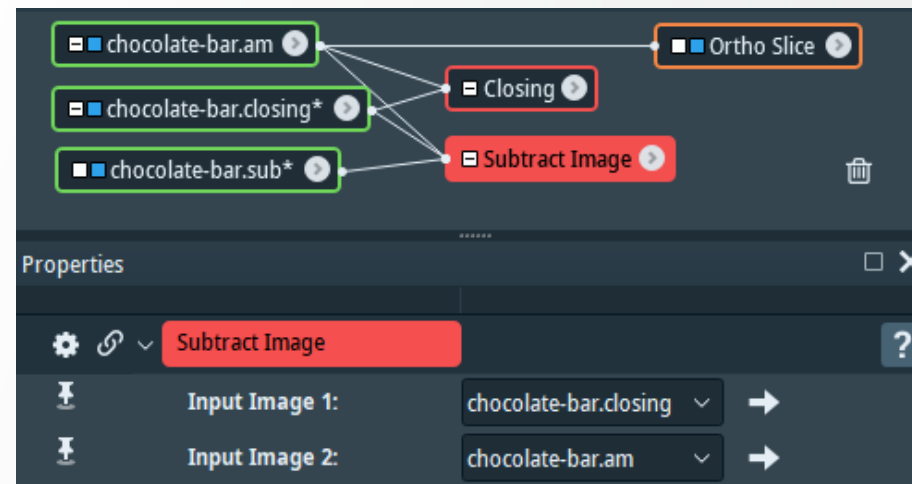
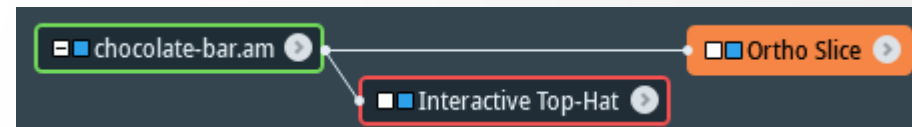


Image segmentation: Top-Hat exercise

Bubble detection in chocolate bar

Apply the necessary module(s) and ports parametrization to create a similar view:

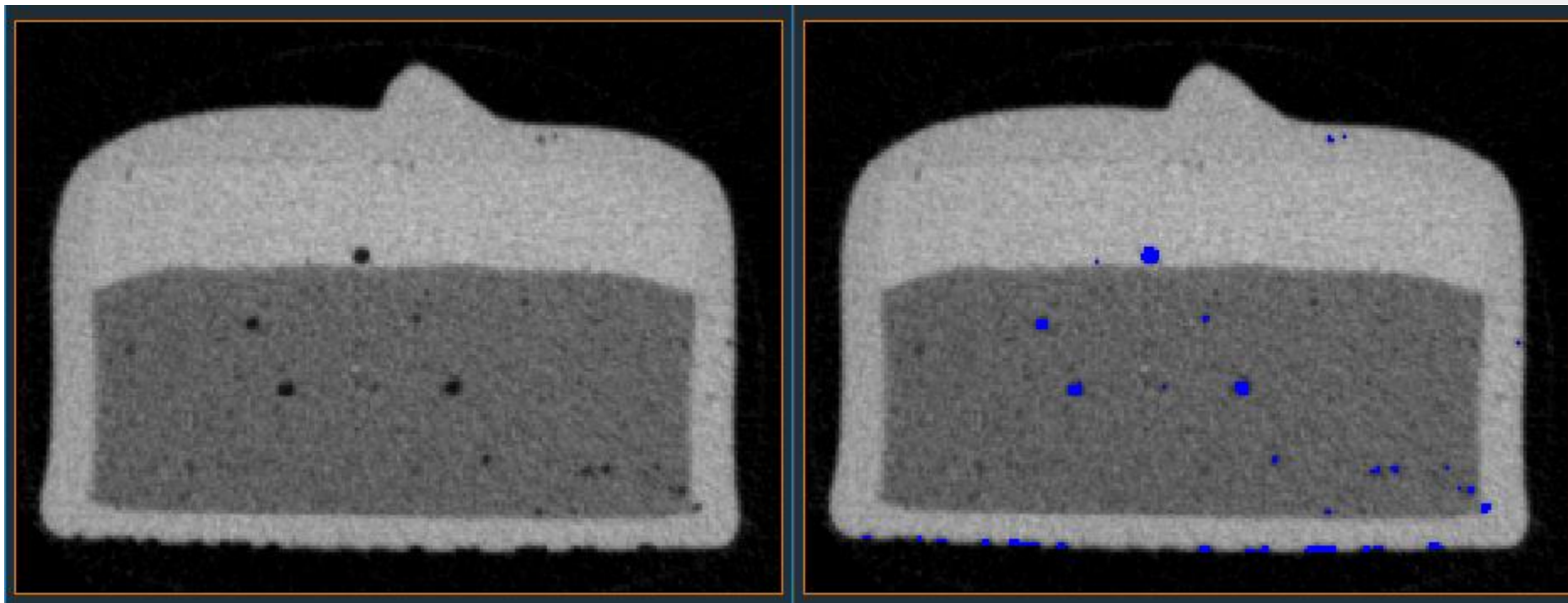


Image segmentation: Top-Hat exercise

Solution

e.g. Interactive Top-Hat module – 2 steps:

- (1/2): Computation of the Black TH transform
- (2/2): Thresholding of the TH transform image

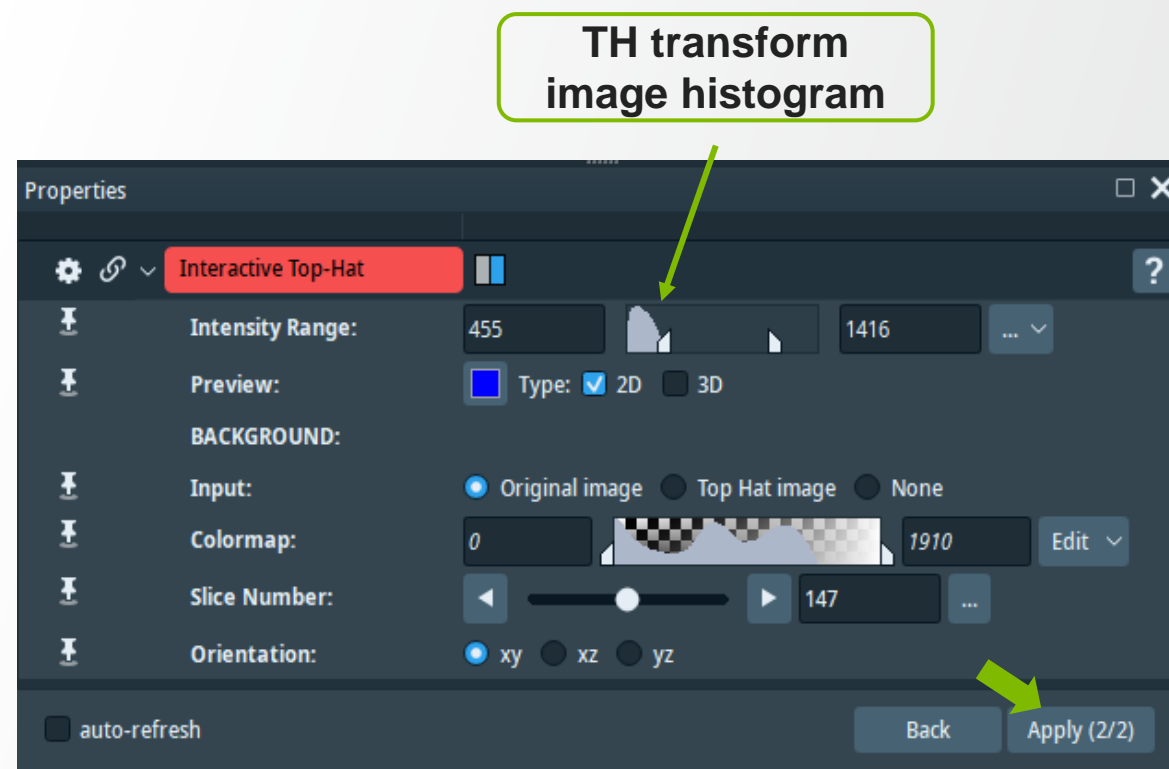
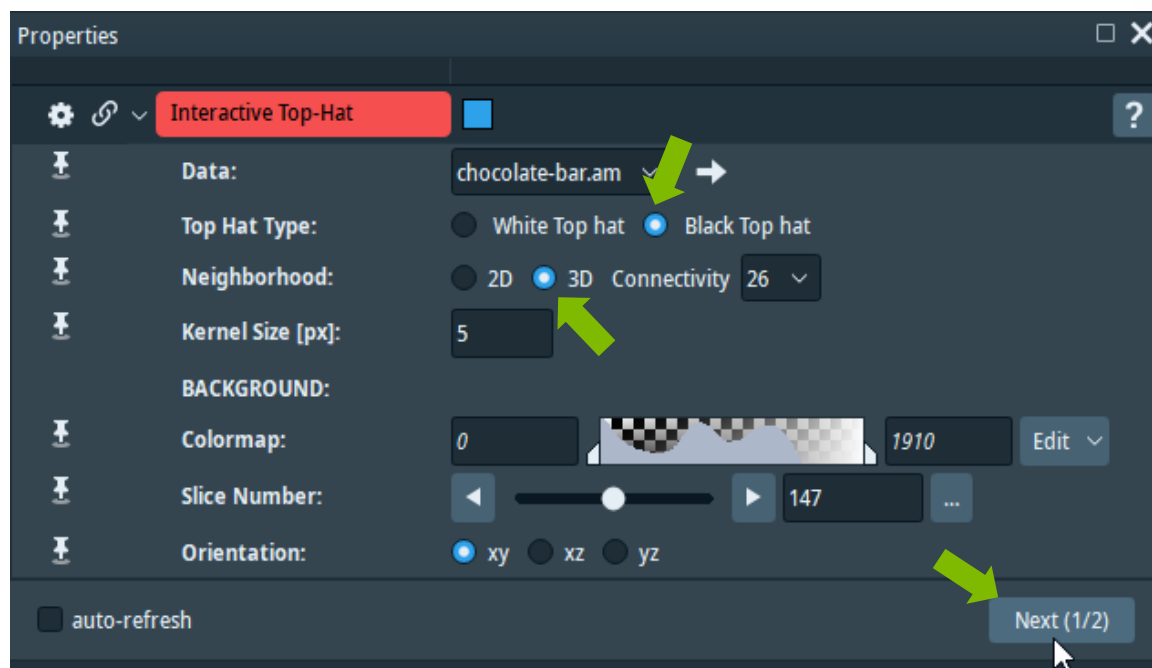
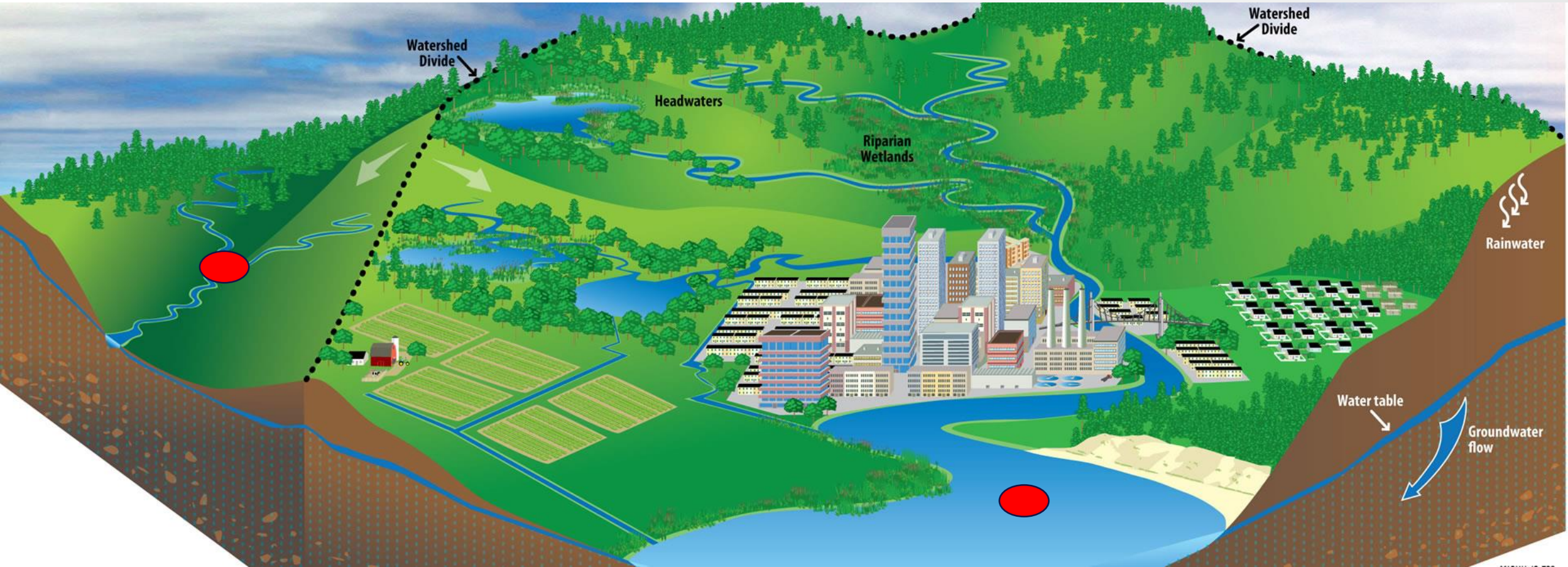
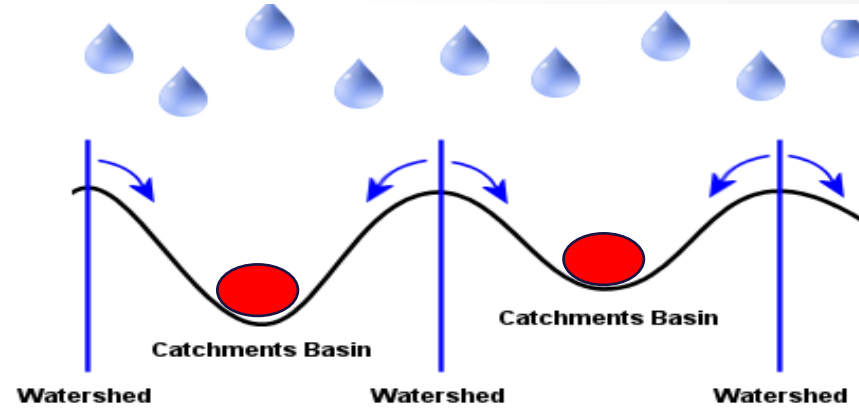


Image segmentation: advanced concepts

Part 2: watershed segmentation

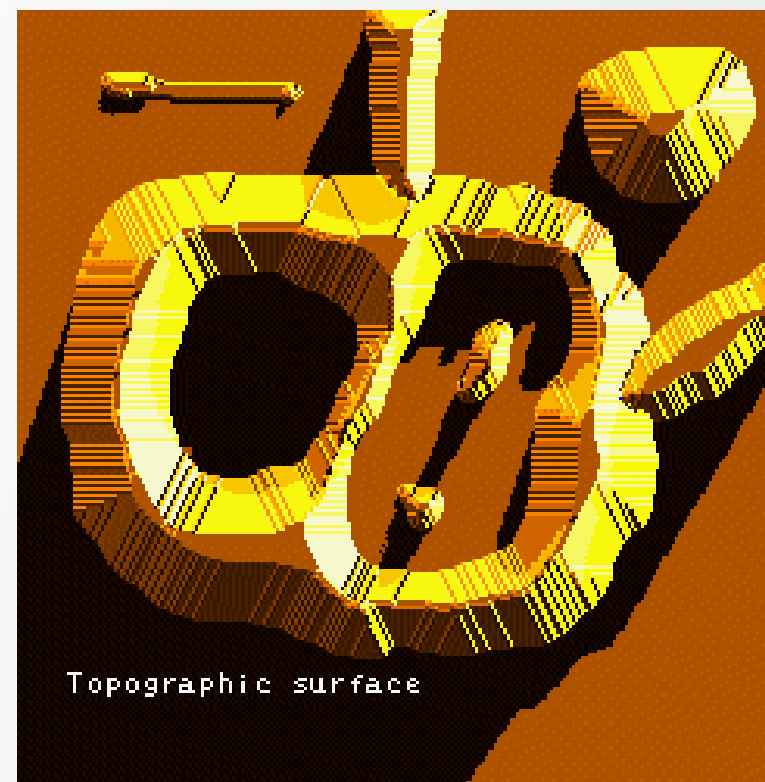
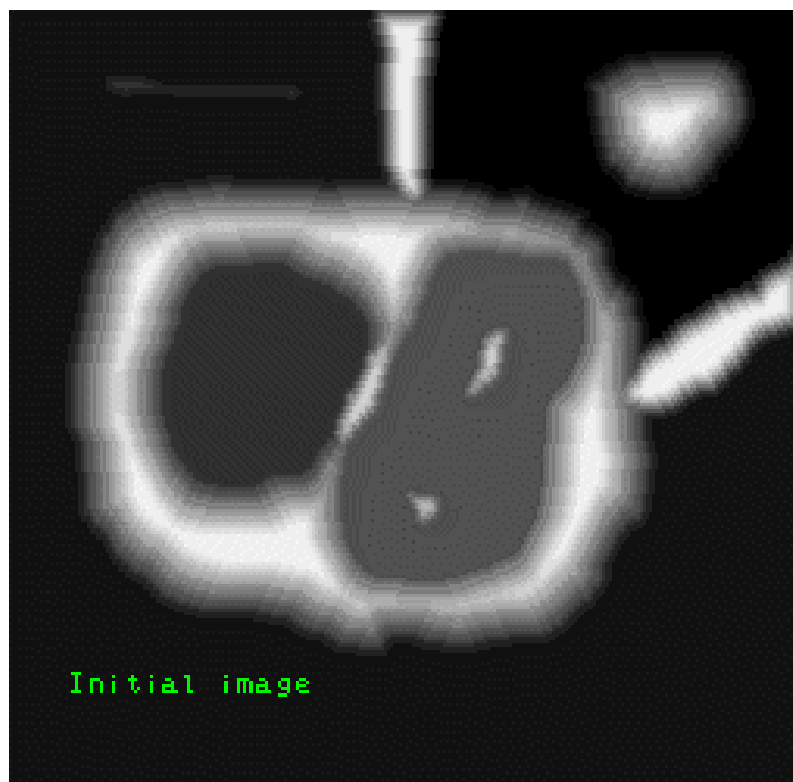
Introduction to Watershed

Watershed is the area of land that drains into catchment basins



Watershed Transformation

Any grayscale image can be considered as a topographic surface.



Watershed Transformation

If we flood this surface from its minima and, if we prevent the merging of the waters coming from different sources, we partition the image into two different sets: the catchment basins and the watershed lines.

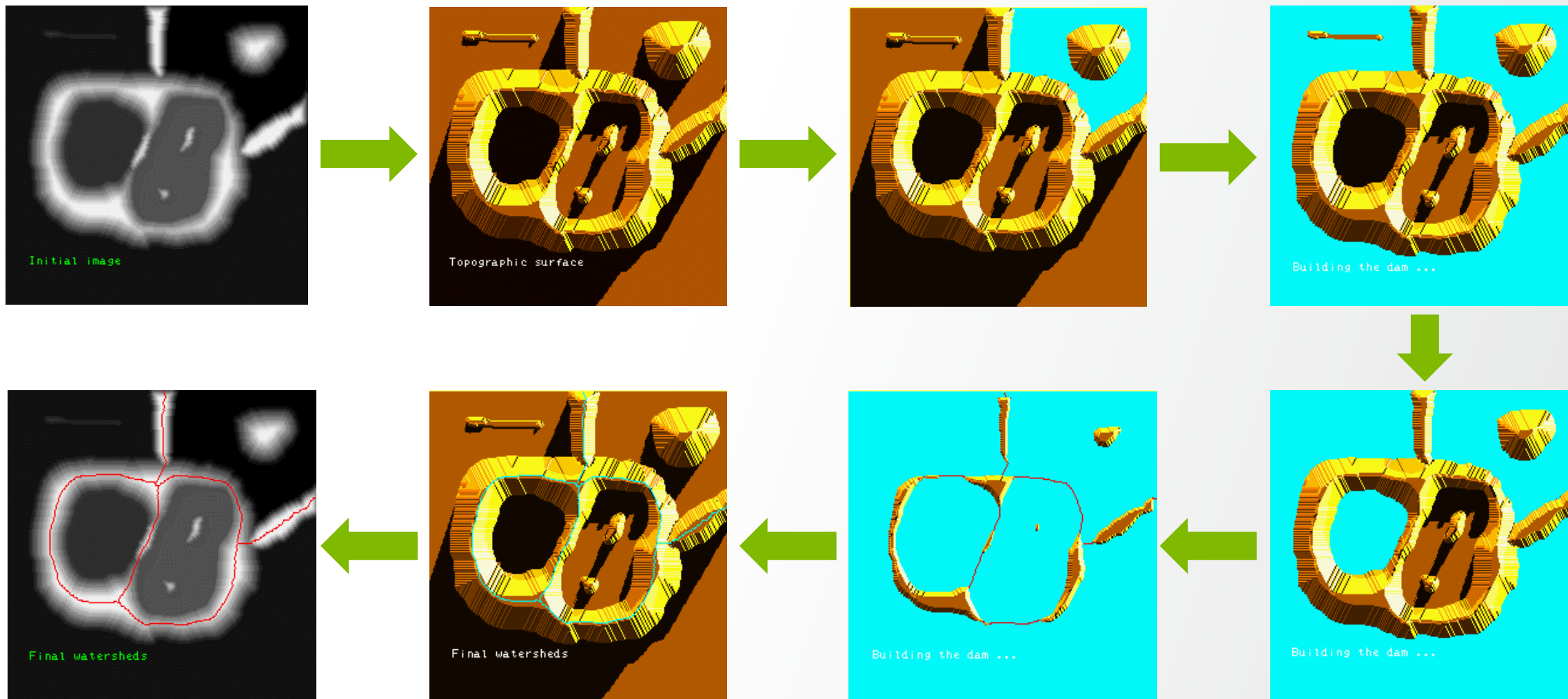


Image gradient

If we apply this transformation to the image gradient, the catchment basins should theoretically correspond to the homogeneous grey level regions of this image.

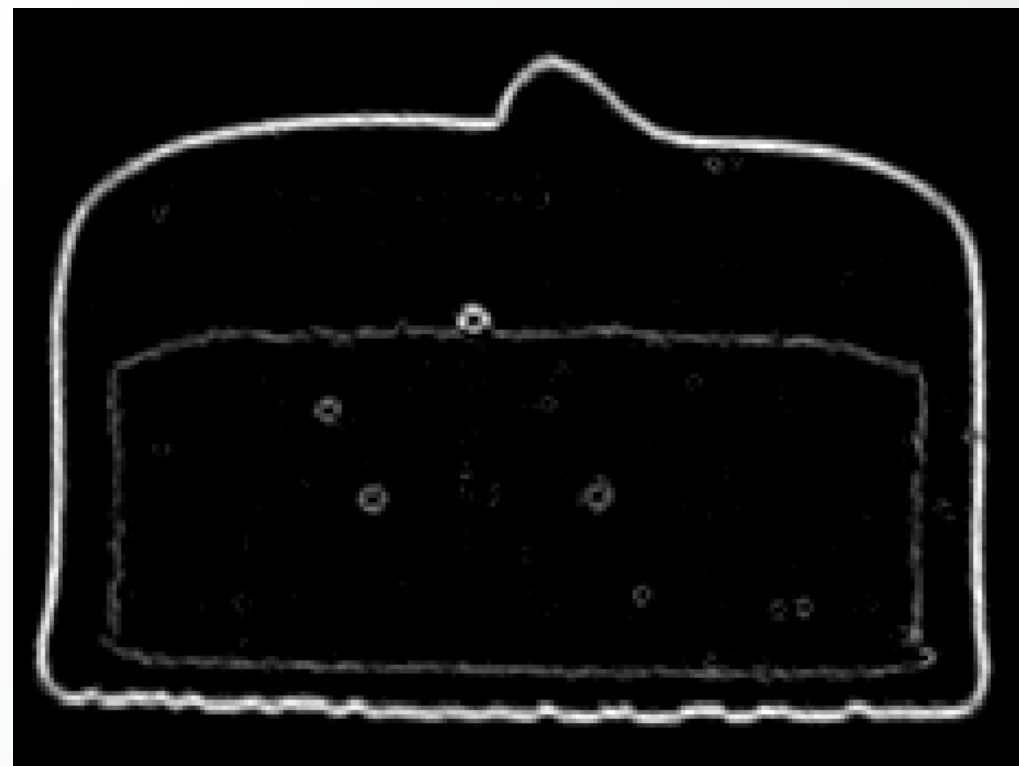
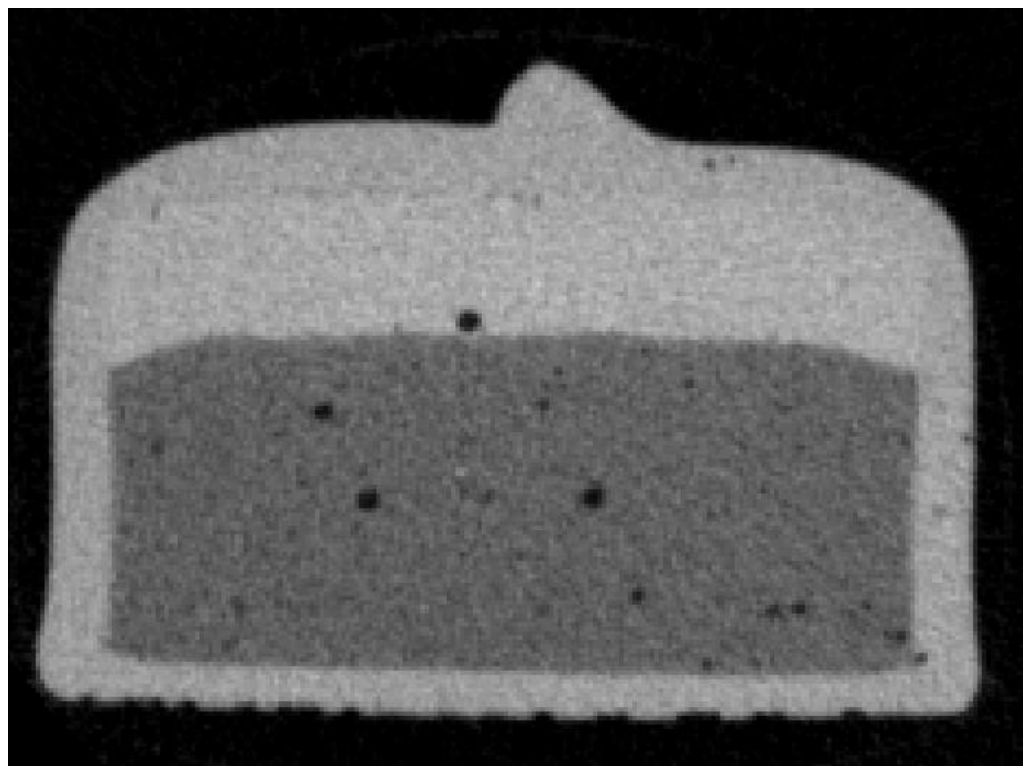
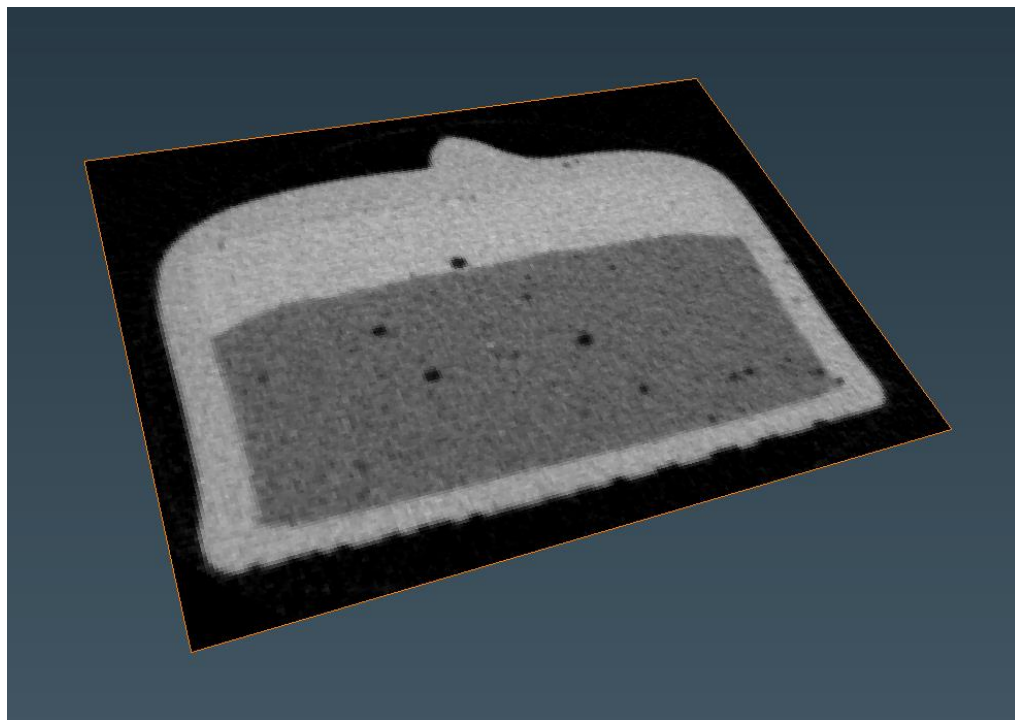


Image gradient

A 2D Image can be viewed as a Height Map. The gradient of an image, computed in each point as the first order spatial derivatives along the x and y directions (dx and dy) gives an estimation of the slope of the equivalent landscape that the image might represent.

Grayscale Image



Gradient = First Order Derivatives

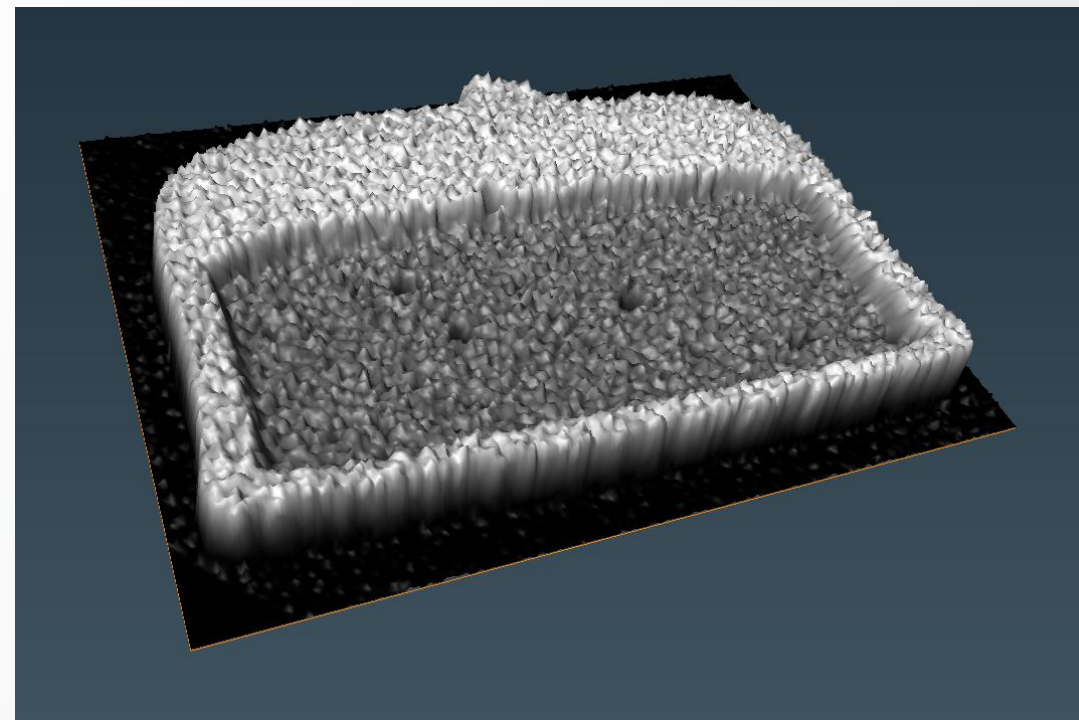


Image gradient

The gradient magnitude – computed as the squared root of the sum of the squared spatial derivatives allows an estimation of the slope steepness.

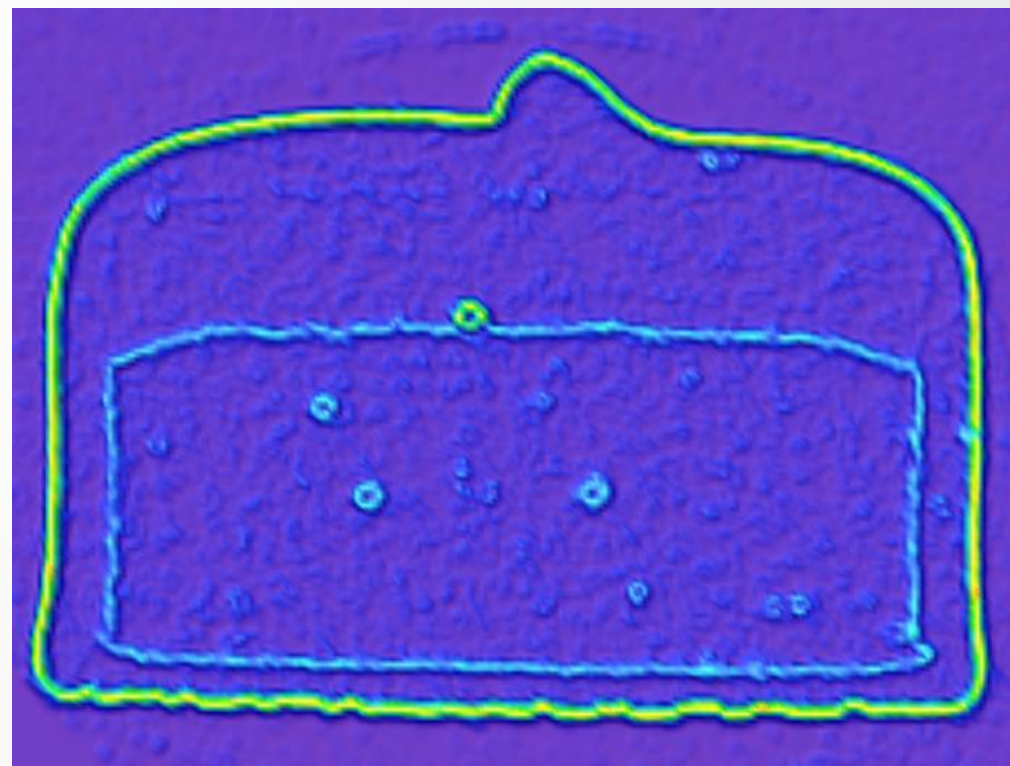
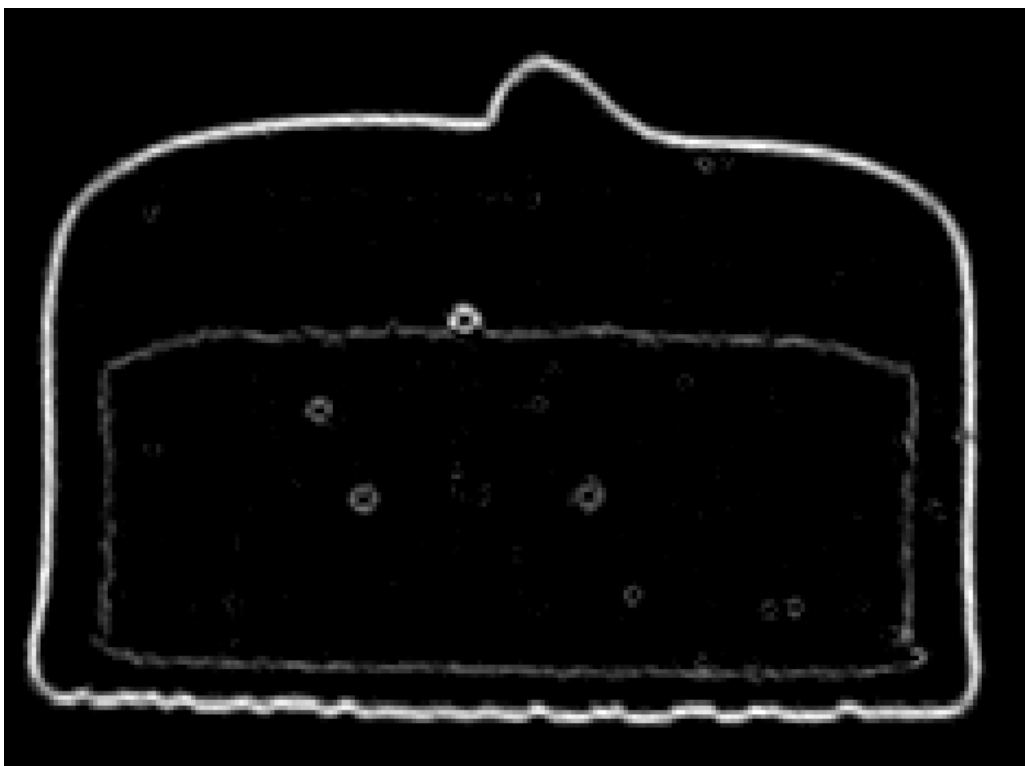
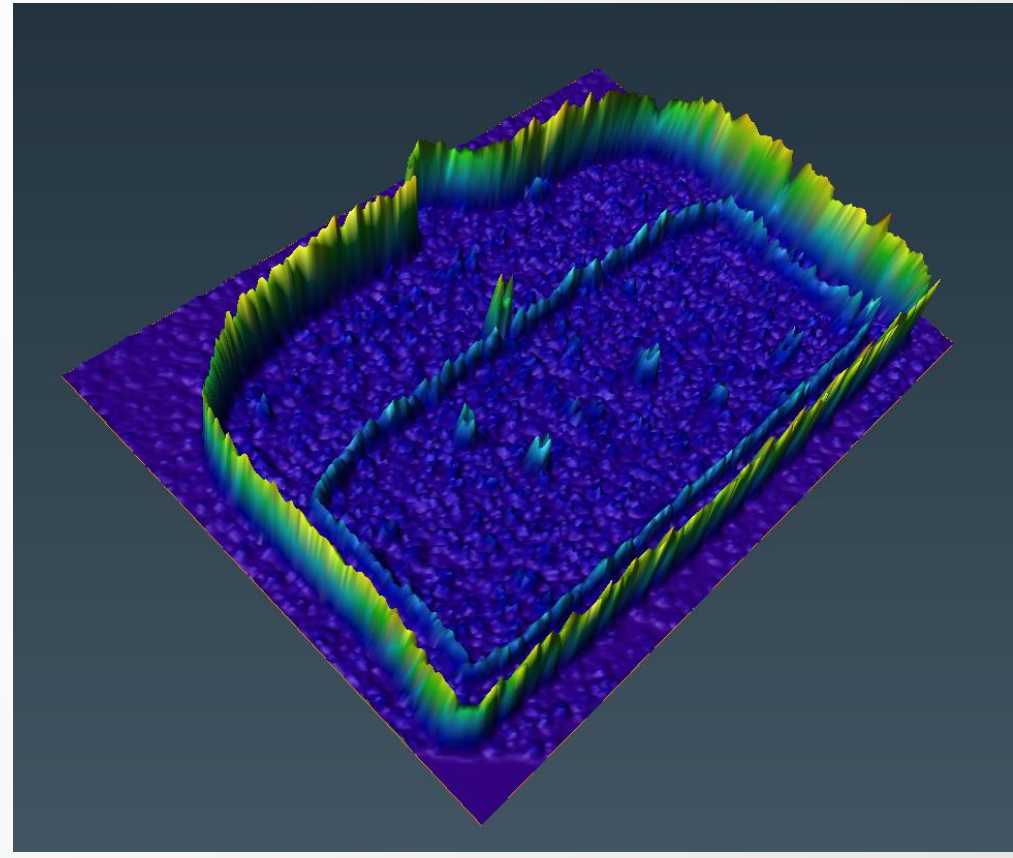
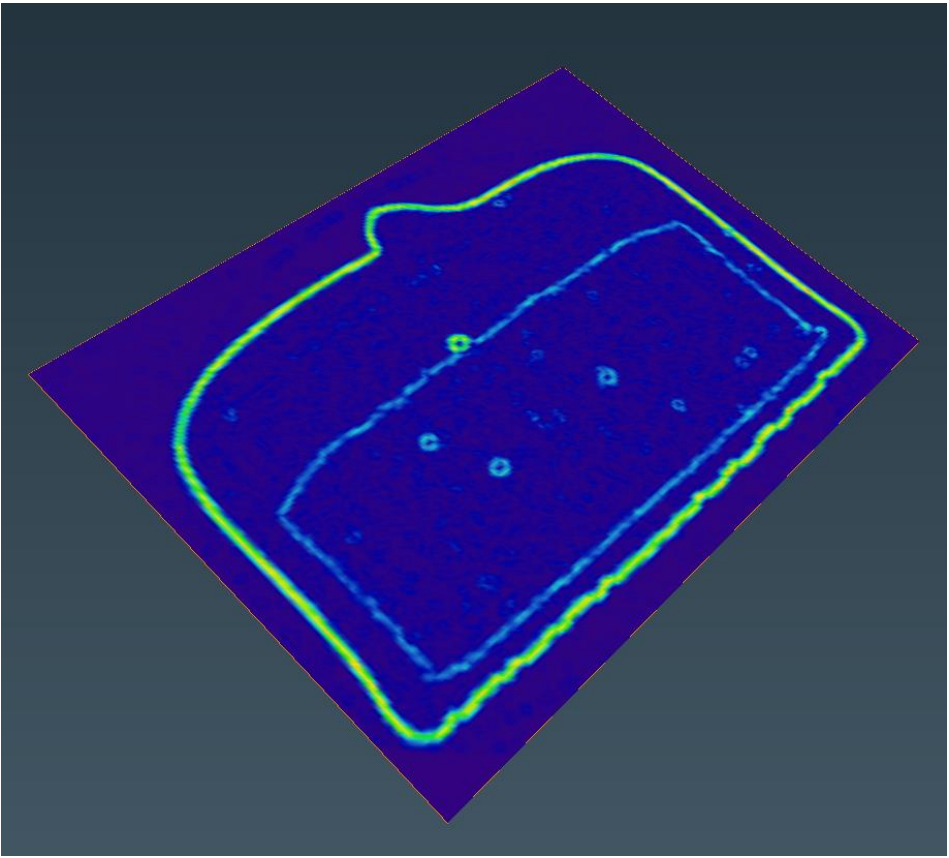


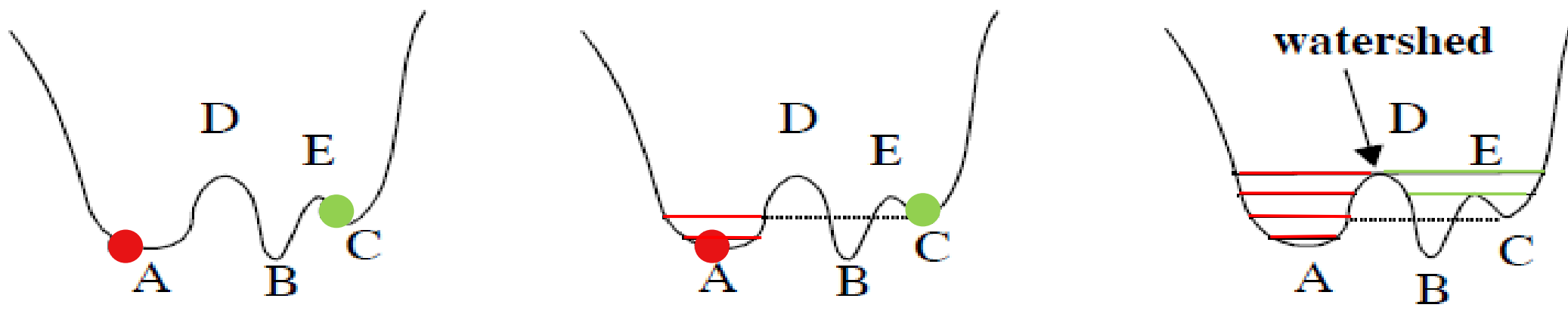
Image gradient

Gradient Magnitude = local steepness \sim contours



Watershed for image segmentation

- Transform grayscale image into gradient image (topographic surface)
- Typically: use the gradient magnitude as **landscape image**
- Simulate flooding of water (markers) in the **landscape image**
- Start from low level landscape (local minima)
- Fill the watershed into the basins with respective markers until reach the watershed line (local maxima)



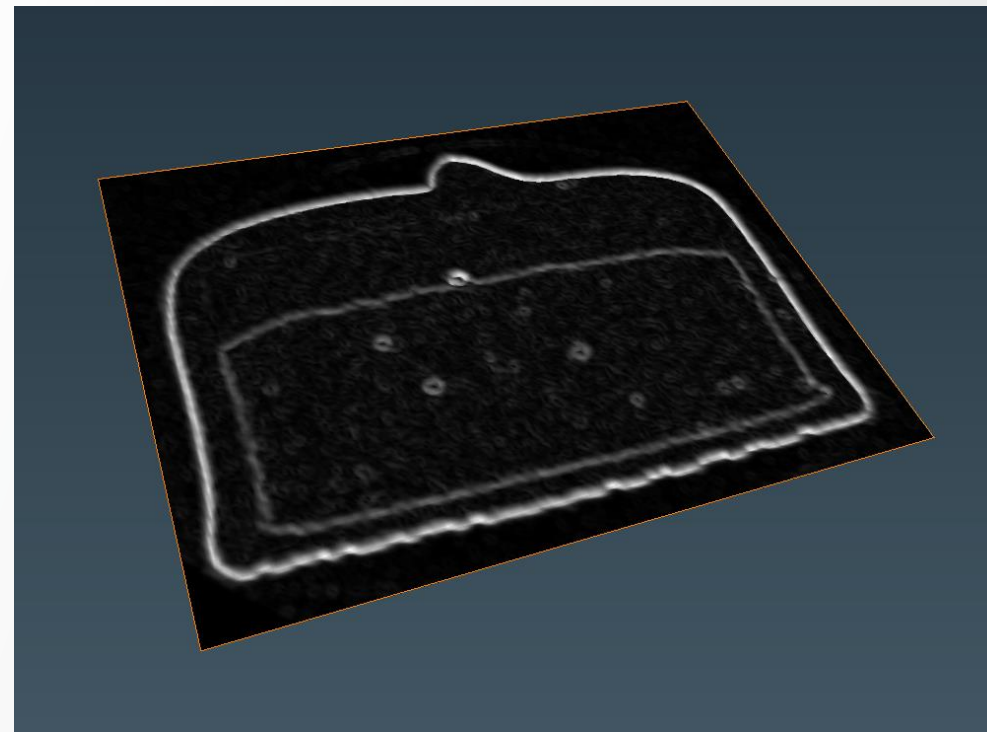
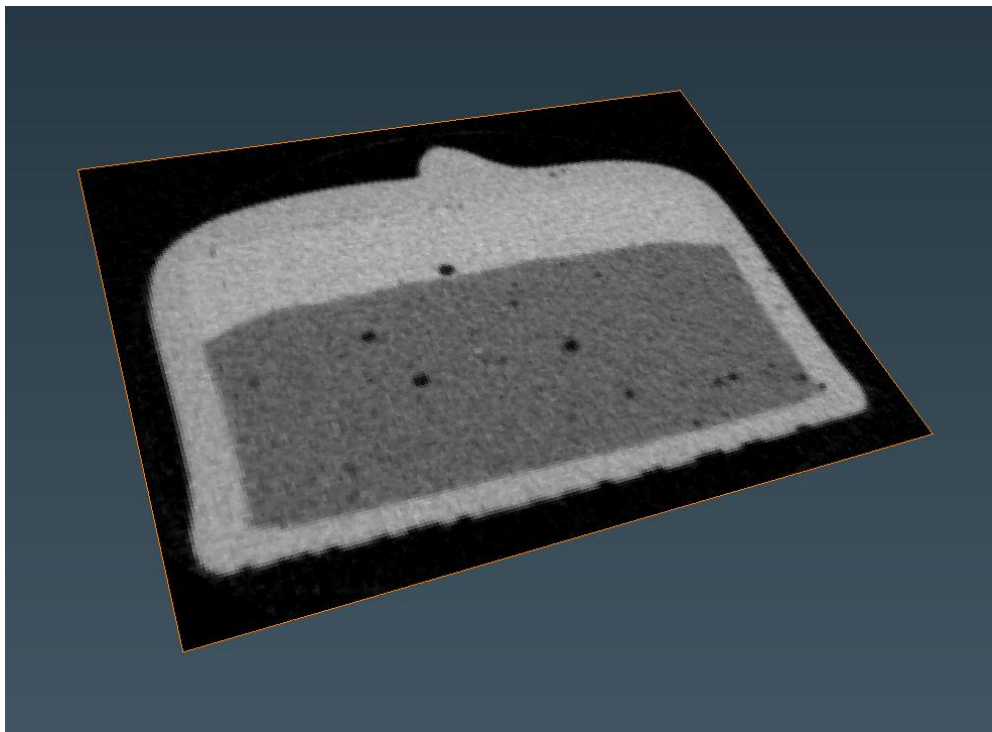
● ● Markers

B,C: Local minima in the landscape image

D,E: Ridges (local maxima) in the landscape image

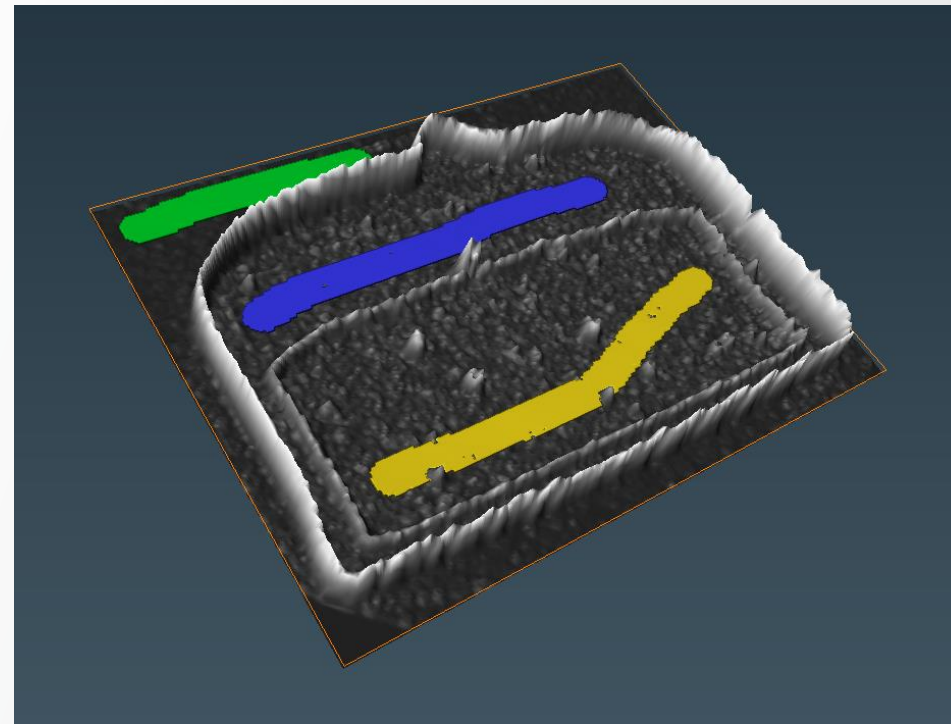
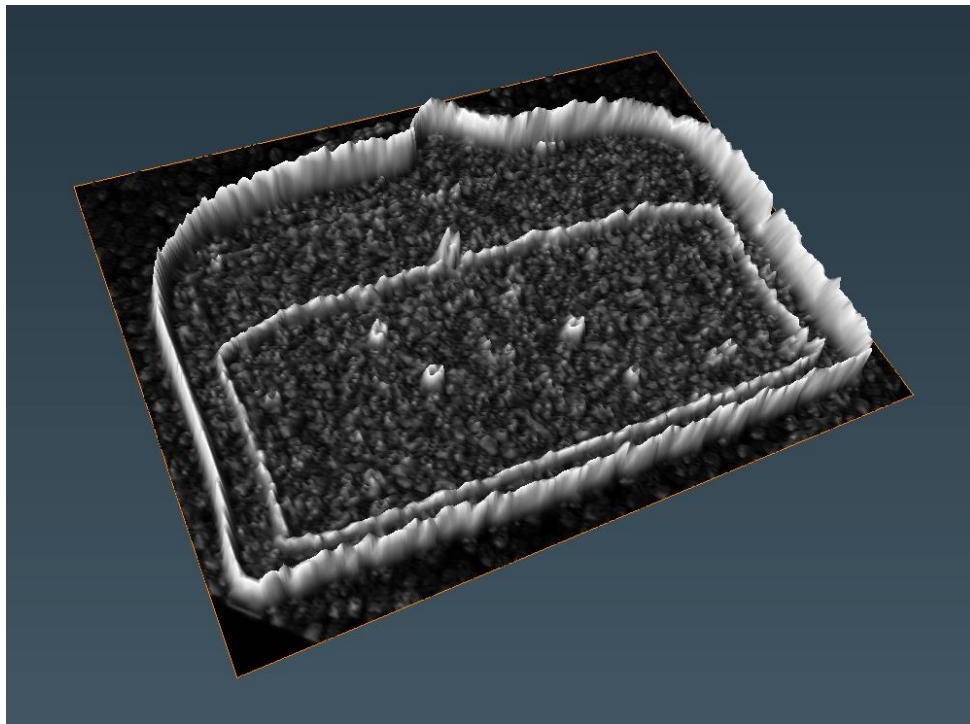
Watershed for image segmentation

- Transform grayscale image into gradient image (topographic surface)
- Typically: use the gradient magnitude as **landscape image**



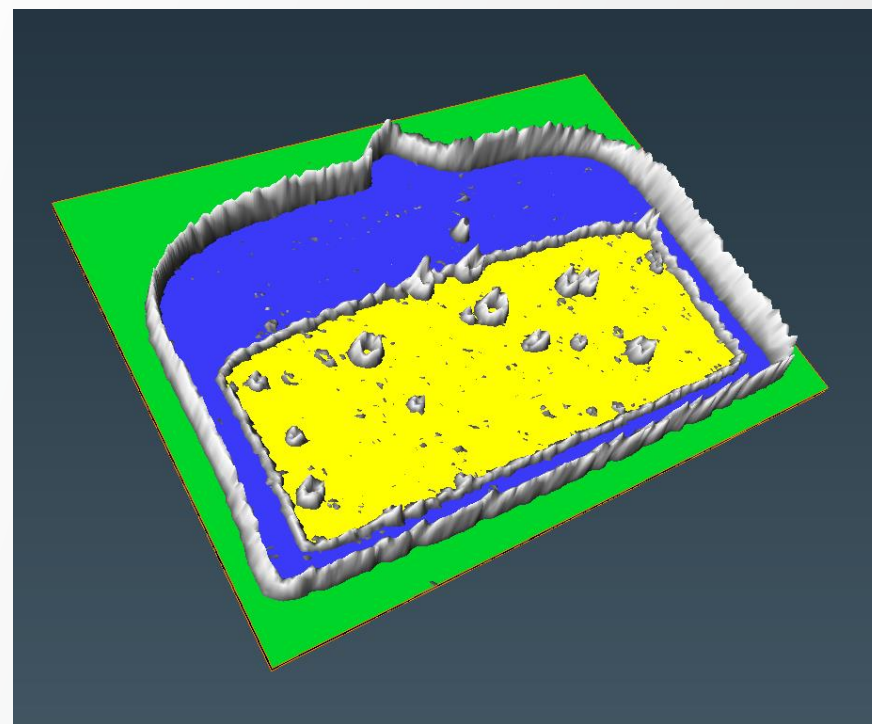
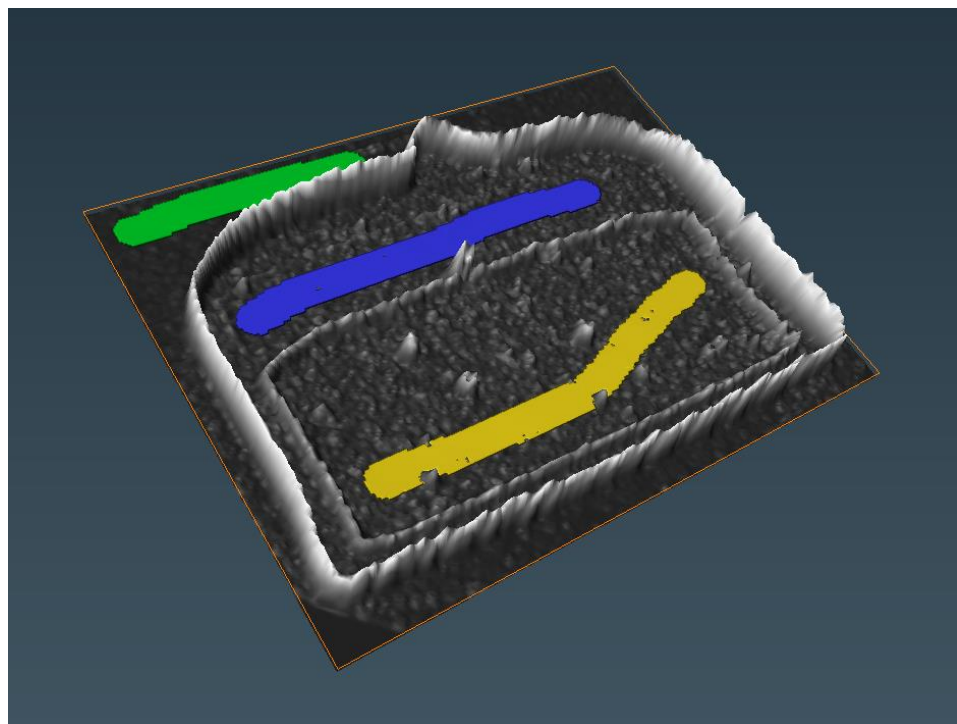
Watershed for image segmentation

- Simulate flooding of water (markers: Green, Blue, Yellow) in the landscape image
- Start from low level landscape (local minima)



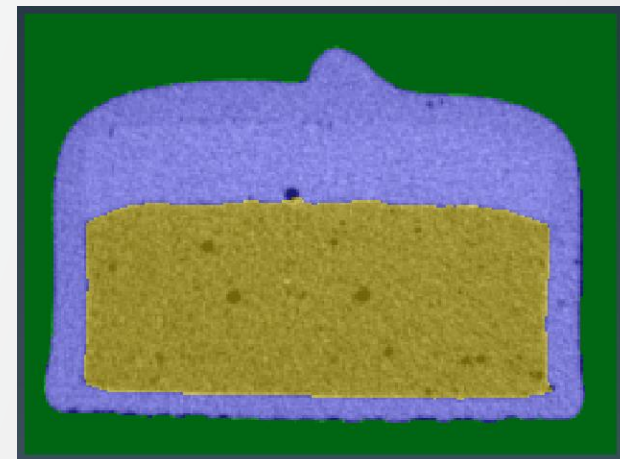
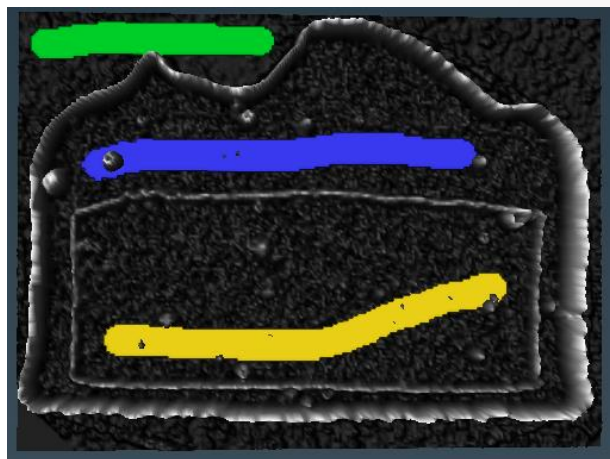
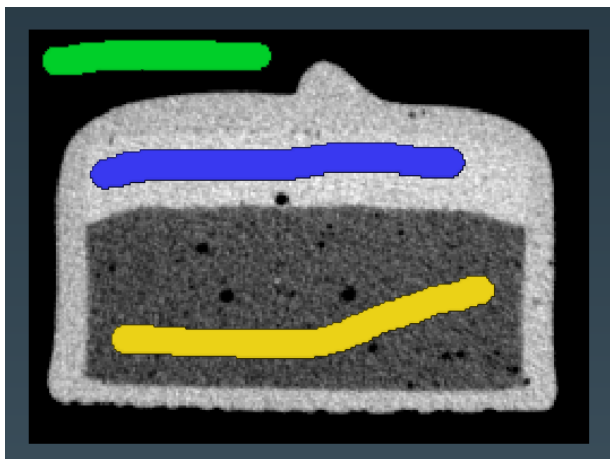
Watershed for image segmentation

- Fill the watershed into the basins with respective markers (Green, Blue, Yellow) until reach the watershed line (local maxima) where two marker sources meet



Marker-based Watershed: Segmentation Editor

- Start with user-defined markers (e.g., brush tool)
- Compute the watersheds (basins) separating the markers (seeds)
- Create a landscape image (Gradient Image) once
- Grow the markers in each Watershed basin



Marker-based Watershed: Segmentation Workroom

The screenshot displays the Segmentation Editor interface for a project named 'chocolate-bar.am'. The 'Label field' is set to 'chocolate-bar.labels'. The 'MATERIALS' table shows two materials: 'Exterior (Not Assigned)' and 'Inside'. The 'Inside' material is selected and highlighted in blue. The 'DISPLAY CONTROL' section shows '2D Crosshairs' is disabled. The 'SELECTION' section shows 'Volume' is selected, 'Show in 3D' is checked, and 'All slices' is checked. The main view shows three 2D slices: XY, YZ, and XZ. The XY slice is at 147 / 294, the YZ slice is at 117 / 234, and the XZ slice is at 87 / 174. The bottom status bar shows 'Pos: 1920 8880 17640', 'Material: Exterior', 'Index: 17 75 148', 'Intensity: 1027', and 'MEMORY USAGE 30%'. A 'Stop' button is visible in the bottom right corner.

File Edit Project View Window XPand Python XScreen Segmentation Selection Help

Start Project **Segmentation** Meshing Recipes Filament Multiplanar Animation

Segmentation Editor

Image: chocolate-bar.am

Label field: chocolate-bar.labels

New Rename Delete

MATERIALS

Color	Name	3D	2D	Colorize	Lock	Select
	Exterior (Not Assigned)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
	Inside	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select

Add Delete Locate

> DISPLAY CONTROL 2D Crosshairs

SELECTION

Volume Current slice Show in 3D No selection

All slices Select all

Pos: 1920 8880 17640 Index: 17 75 148
Material: Exterior Intensity: 1027

XY 2:1 147 / 294

YZ 117 / 234

XZ 87 / 174

Stop MEMORY USAGE 30%

Segmentation Editor: 3D Viewer position

The default **3D Viewer position** in Avizo is “Upper Left”. You can switch it to “Bottom Right” from: Edit -> Preferences -> Segmentation

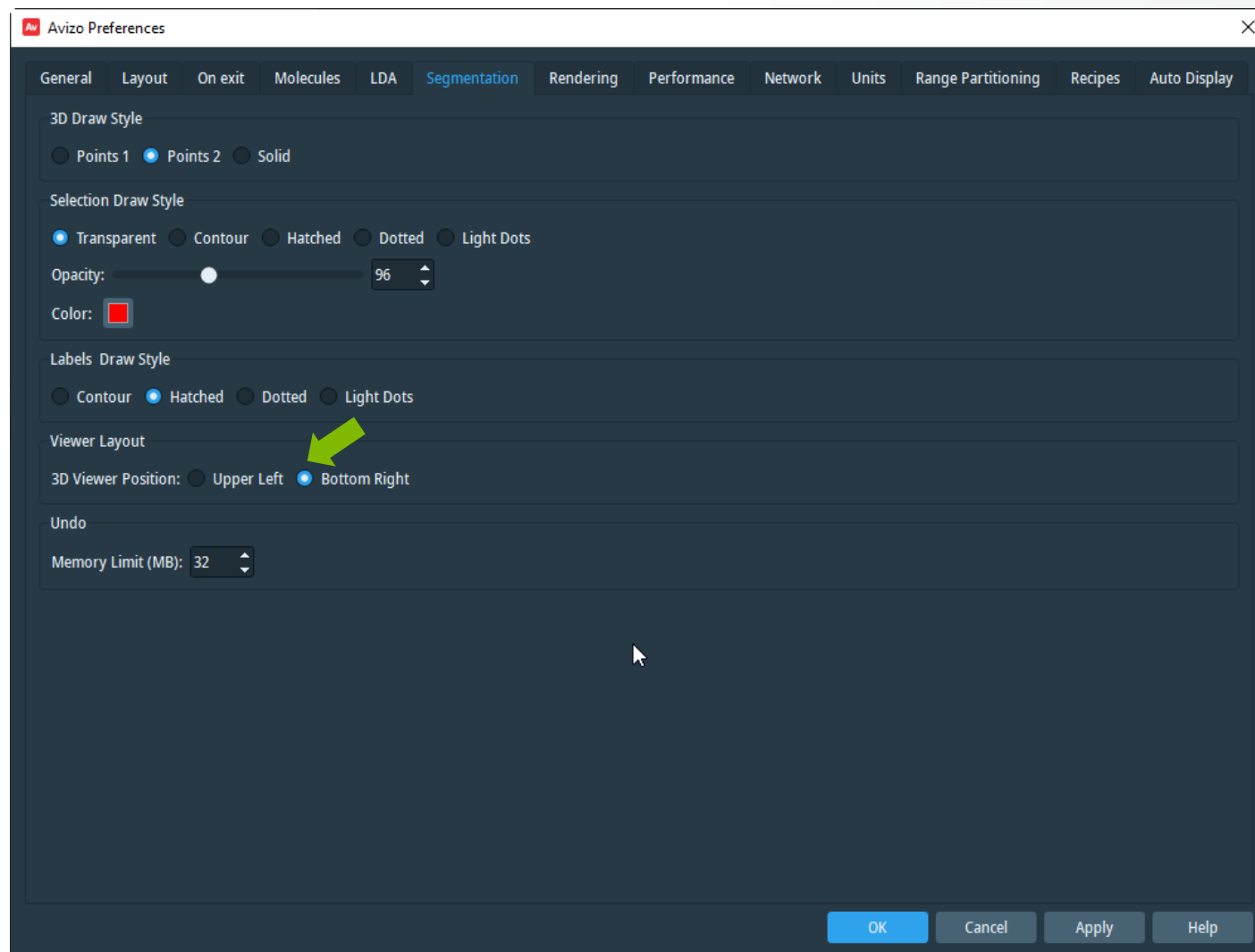


Image segmentation: Marker-based Watershed

The screenshot displays the ThermoFisher Scientific software interface for image segmentation. The main window is titled "Segmentation Editor" and shows a 3D view of a chocolate bar cross-section. The interface is divided into several panels:

- Menu Bar:** File, Edit, Project, View, Window, XPand, Python, XScreen, Segmentation, Selection, Help.
- Toolbar:** Start, Project, Segmentation, Meshing, Recipes, Filament, Multiplanar, Animation.
- Segmentation Editor Panel (Left):**
 - Image:** chocolate-bar.am
 - Label field:** chocolate-bar.labels
 - MATERIALS Table:**

Color	Name	3D	2D	Colorize	Lock	Select
White	Exterior (Not Assigned)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Green	Material_1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Blue	Material_2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Yellow	Material_3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
 - Buttons:** Add, Delete, Locate.
 - DISPLAY CONTROL:** 2D (-24), 3D (478), 2D Crosshairs, Crosshairs, Slices, Volume rendering.
 - SELECTION:** Volume, Current slice, Show in 3D, No selection.
- 3D View (Right):** Shows a 3D rendering of the chocolate bar cross-section. The view is split into four quadrants: XY, YZ, XZ, and a central view with a red box and crosshairs. The XY view shows a white chocolate coating over a darker filling. The YZ and XZ views show different cross-sections of the bar. The central view shows a red box and crosshairs, likely indicating a region of interest for segmentation.

Image segmentation: Marker-based Watershed

The screenshot displays the ThermoFisher software interface for image segmentation. The main window shows a 3D volume of a chocolate bar with a marker-based watershed segmentation. The interface is divided into several panels:

- Segmentation Editor:** Shows the image name "chocolate-bar.am" and the label field "chocolate-bar.labels". It includes buttons for "New", "Rename", and "Delete".
- MATERIALS:** A table listing materials with their colors and properties. "Material_1" is highlighted in blue.
- DISPLAY CONTROL:** Shows 2D and 3D slice indices (0 and 478) and various display options like "Crosshairs", "Slices", and "Volume rendering".
- SELECTION:** Includes tools for selection and a brush size slider set to 25.

The 3D view shows a chocolate bar with a red brush stroke on its top surface, labeled "4". The 2D slice view shows the resulting segmentation, also labeled "4".

Color	Name	3D	2D	Colorize	Lock	Select
Grey	Exterior (Not Assigned)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Blue	Material_1	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Red	Material_2	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Yellow	Material_3	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select

Image segmentation: Marker-based Watershed

The screenshot displays the ThermoFisher software interface for image segmentation. The main window shows a 3D volume of a chocolate bar with a red marker on the top surface. A 2D XY slice is shown below, displaying the watershed segmentation result. The interface includes a menu bar, a toolbar, and several panels:

- Segmentation Editor:** Shows the image name "chocolate-bar.am" and the label field "chocolate-bar.labels".
- MATERIALS:** A table listing materials with their colors and 3D/2D visibility options.
- DISPLAY CONTROL:** Controls for 2D and 3D views, including crosshairs and volume rendering.
- SELECTION:** Tools for selecting and manipulating the volume.

Color	Name	3D	2D	Colorize	Lock	Select
Grey	Exterior (Not Assigned)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Green	Material_1	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Blue	Material_2	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Yellow	Material_3	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select

A large green number "5" is overlaid on the interface, with arrows pointing to the "Material_1" row in the MATERIALS table, the "Add" button, and the "SELECTION" panel. A red marker is visible on the top surface of the chocolate bar in the 3D view, and a red rectangular region is highlighted in the 2D XY slice, indicating the area where the marker-based watershed segmentation is applied.

Image segmentation: Marker-based Watershed

File Edit Project View Window XPand Python XScreen Segmentation Selection Help

Start Project Segmentation Meshing Recipes Filament Multiplanar Animation

Segmentation Editor

Image: chocolate-bar.am

Label field: chocolate-bar.labels

MATERIALS

Color	Name	3D	2D	Colorize	Lock	Select
	Exterior (Not Assigned)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Green	Material_1	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Blue	Material_2	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Yellow	Material_3	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select

DISPLAY CONTROL

2D 0 1302 Edit

3D 478 1910 Edit Option

Crosshairs Slices Volume rendering

SELECTION

Volume Current slice Show in 3D No selection

Auto hide cursor Select only current material

Square brush

Masking 478 1910 Edit Enable

Preview 2D 3D

Pos: 11160 1320 17640 Index: 94 12 148 Intensity: 0

XY 147 / 294

YZ 117 / 234

XZ 87 / 174

Image segmentation: Marker-based Watershed

The screenshot displays the ThermoFisher Scientific software interface for image segmentation. The main window shows a 3D volume of a chocolate bar with three 2D slices (XY, YZ, XZ) visible. A red marker is applied to the top layer of the chocolate bar in the XY slice. The Segmentation Editor on the left contains a materials list with the following items:

Color	Name	3D	2D	Colorize	Lock	Select
White	Exterior (Not Assigned)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Green	Material_1	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Blue	Material_2	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Yellow	Material_3	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select

Green arrows labeled '6' and '7' point to the materials list and the brush tool, respectively. The brush tool is currently set to a size of 25. The XY slice shows a red marker on the top layer of the chocolate bar. The YZ and XZ slices show the corresponding cross-sections. The XY slice is zoomed in to 2:1. The YZ slice is at 117 / 234 and the XZ slice is at 87 / 174. The software interface includes a menu bar (File, Edit, Project, View, Window, XPand, Python, XScreen, Segmentation, Selection, Help) and a toolbar with various icons for navigation and editing.

Image segmentation: Marker-based Watershed

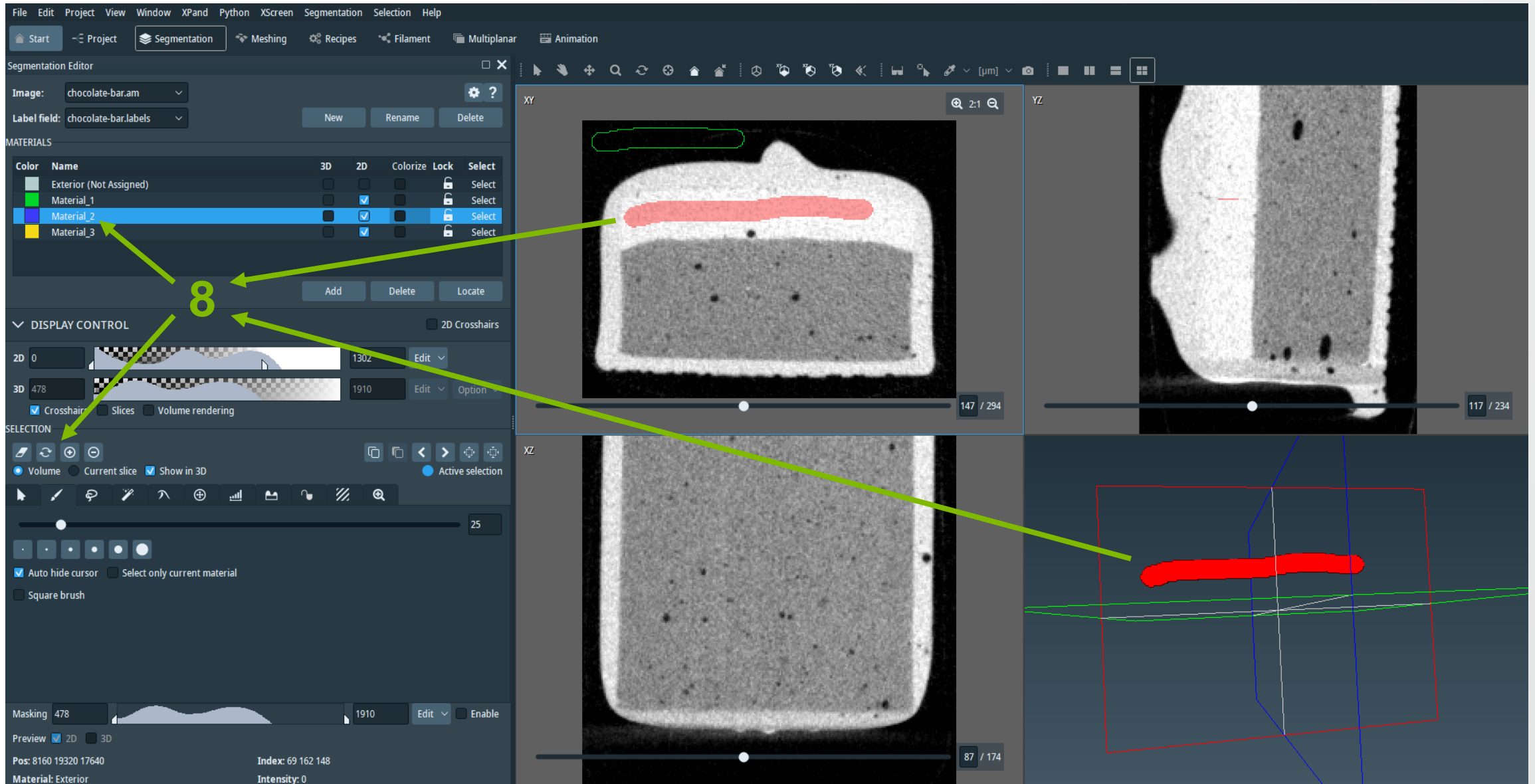


Image segmentation: Marker-based Watershed

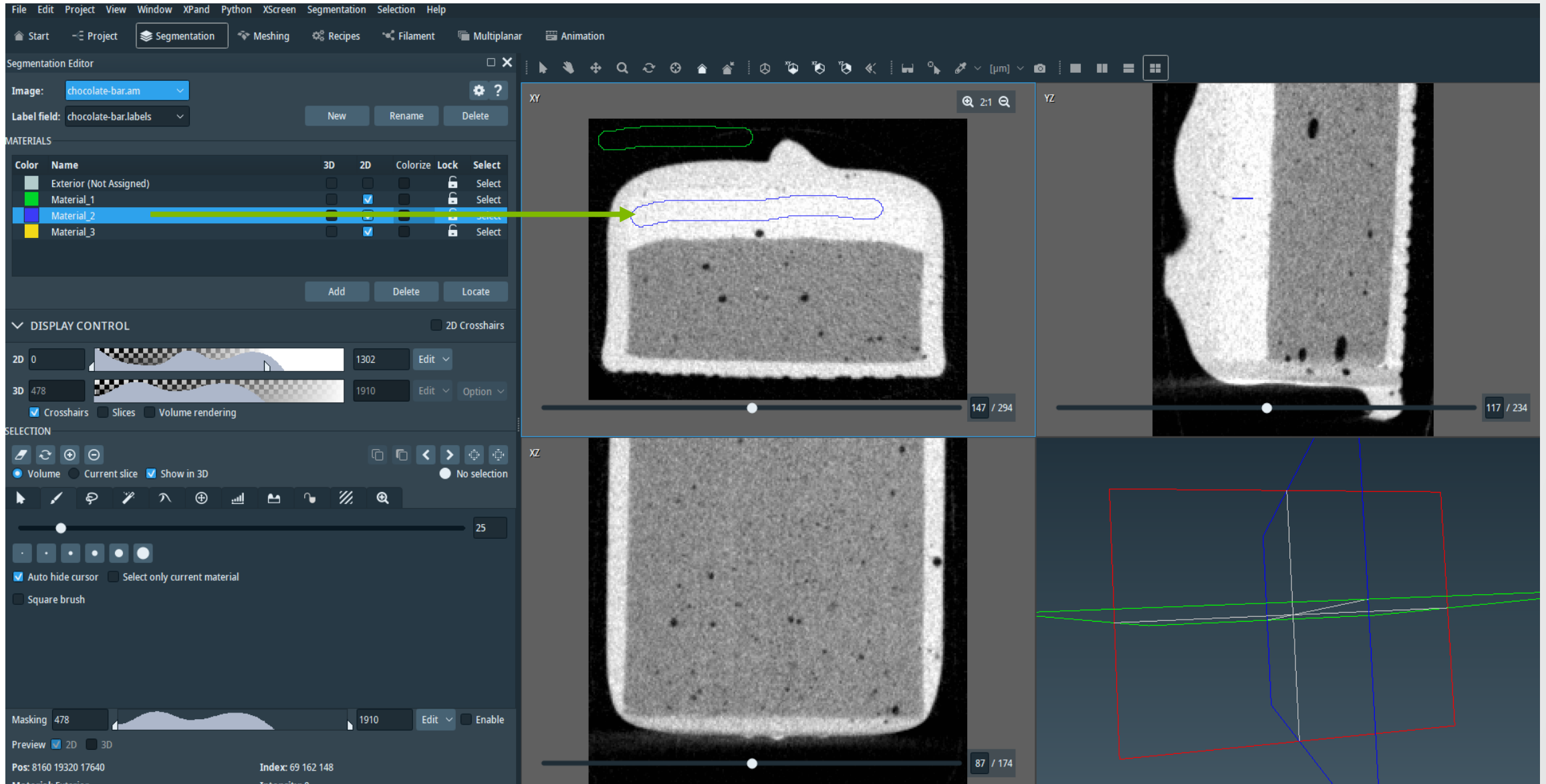


Image segmentation: Marker-based Watershed

The screenshot displays the ThermoFisher software interface for image segmentation. The left panel, titled "Segmentation Editor", shows the "Image" field set to "chocolate-bar.am" and the "Label field" set to "chocolate-bar.labels". Below this is a "MATERIALS" table:

Color	Name	3D	2D	Colorize	Lock	Select
Grey	Exterior (Not Assigned)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Green	Material_1	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Blue	Material_2	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Yellow	Material_3	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select

Below the materials table is the "DISPLAY CONTROL" section, which includes a "2D" view (0) and a "3D" view (478). The "3D" view is currently selected. The "SELECTION" section shows the "Volume" selected, and the "Active selection" is set to "Volume". The "Brush" size is set to 25. The "Masking" section shows the "Masking" value set to 478. The "Preview" section shows the "2D" view selected. The "Pos:" and "Material:" fields are also visible.

The right panel shows a 3D view of the chocolate bar with segmented regions. The top view (XY) shows the chocolate bar with a red region (Material_3) and a blue region (Material_2). The side view (YZ) shows the chocolate bar with a red region (Material_3) and a blue region (Material_2). The bottom view (XZ) shows the chocolate bar with a red region (Material_3) and a blue region (Material_2). The number "10" is overlaid on the red region in all three views, indicating the segmentation result. Green arrows point from the "Material_3" row in the materials table to the red region in the 3D view, and from the "Brush" size slider to the red region in the 3D view.

Image segmentation: Marker-based Watershed

The screenshot displays the ThermoFisher software interface for image segmentation. The main window shows a 3D volume rendering of a chocolate bar cross-section, with three 2D slices (XY, YZ, XZ) visible. The XY slice shows a red brush stroke and a blue outline. The YZ slice shows a blue and red line. The XZ slice shows a red brush stroke. The Segmentation Editor panel on the left shows the image 'chocolate-bar.am' and label field 'chocolate-bar.labels'. The MATERIALS table lists 'Exterior (Not Assigned)', 'Material_1', 'Material_2', and 'Material_3'. The DISPLAY CONTROL panel shows 2D and 3D views. The SELECTION panel shows 'Volume' selected. The interface also includes a menu bar (File, Edit, Project, View, Window, XPand, Python, XScreen, Segmentation, Selection, Help) and a toolbar with various tools.

Color	Name	3D	2D	Colorize	Lock	Select
Grey	Exterior (Not Assigned)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Green	Material_1	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Blue	Material_2	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Yellow	Material_3	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select

Image segmentation: Marker-based Watershed

The screenshot displays the ThermoFisher Scientific software interface for image segmentation. The main window shows a 3D view of a chocolate bar cross-section with segmented regions outlined in green, blue, and yellow. The XY plane view shows the top-down view of the bar, the YZ plane shows a side view, and the XZ plane shows a front view. A green arrow points from the 'Material_3' entry in the materials list to the yellow outline in the XY plane.

Segmentation Editor

Image: chocolate-bar.am
Label field: chocolate-bar.labels

MATERIALS

Color	Name	3D	2D	Colorize	Lock	Select
White	Exterior (Not Assigned)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Green	Material_1	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Blue	Material_2	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select
Yellow	Material_3	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select

DISPLAY CONTROL

2D 0 1302 Edit
3D 478 1910 Edit Option
 Crosshairs Slices Volume rendering

SELECTION

Volume Current slice Show in 3D No selection

Masking 478 1910 Edit Enable
Preview 2D 3D
Pos: Index: Material: Intensity:

Image segmentation: Marker-based Watershed

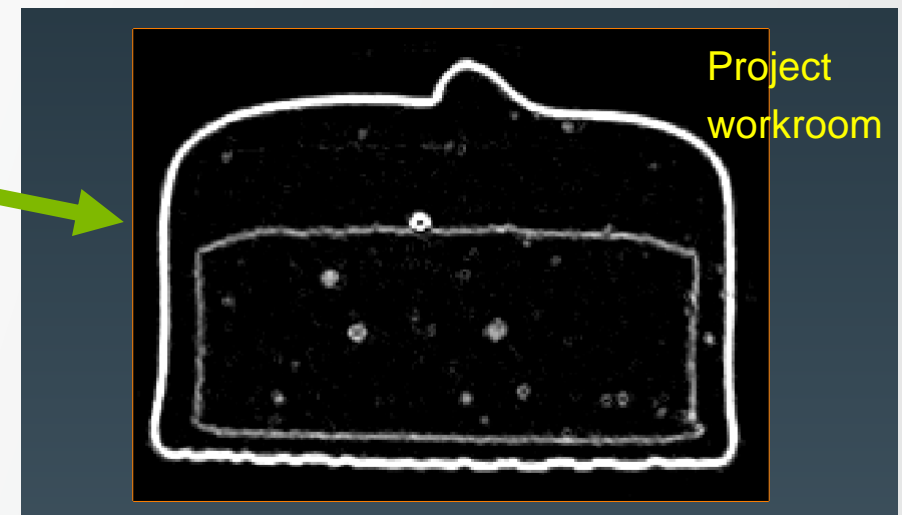
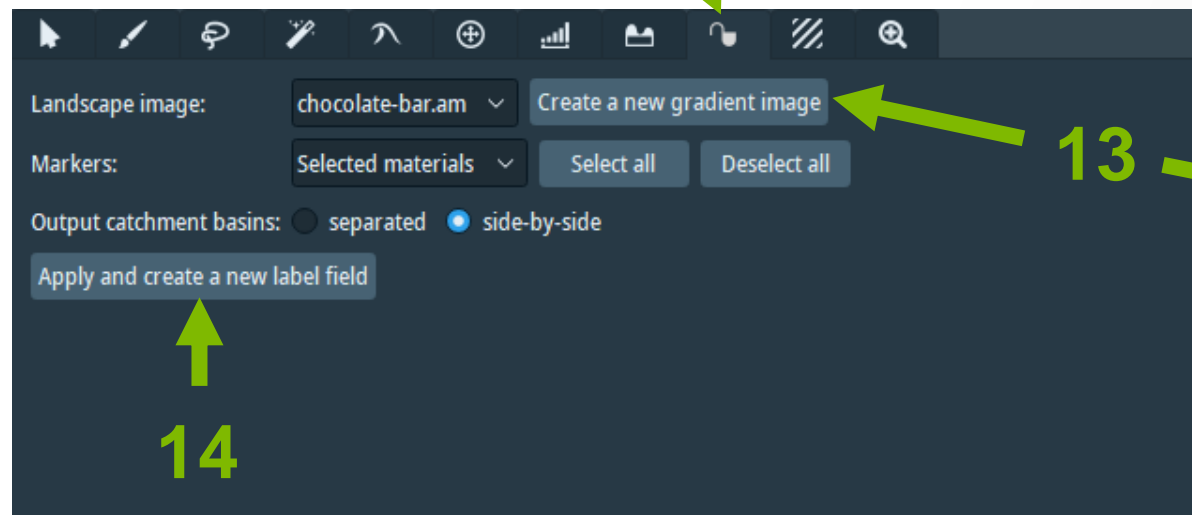
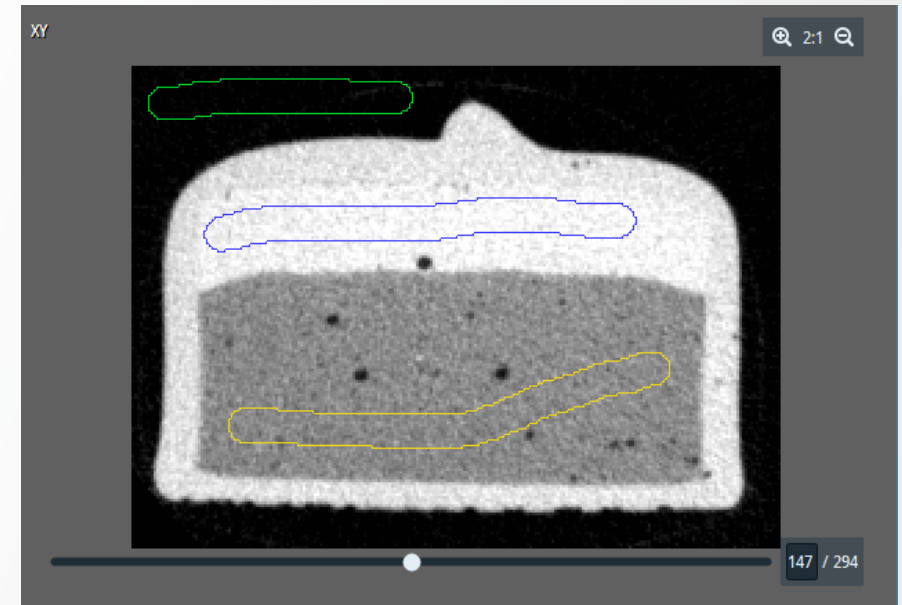
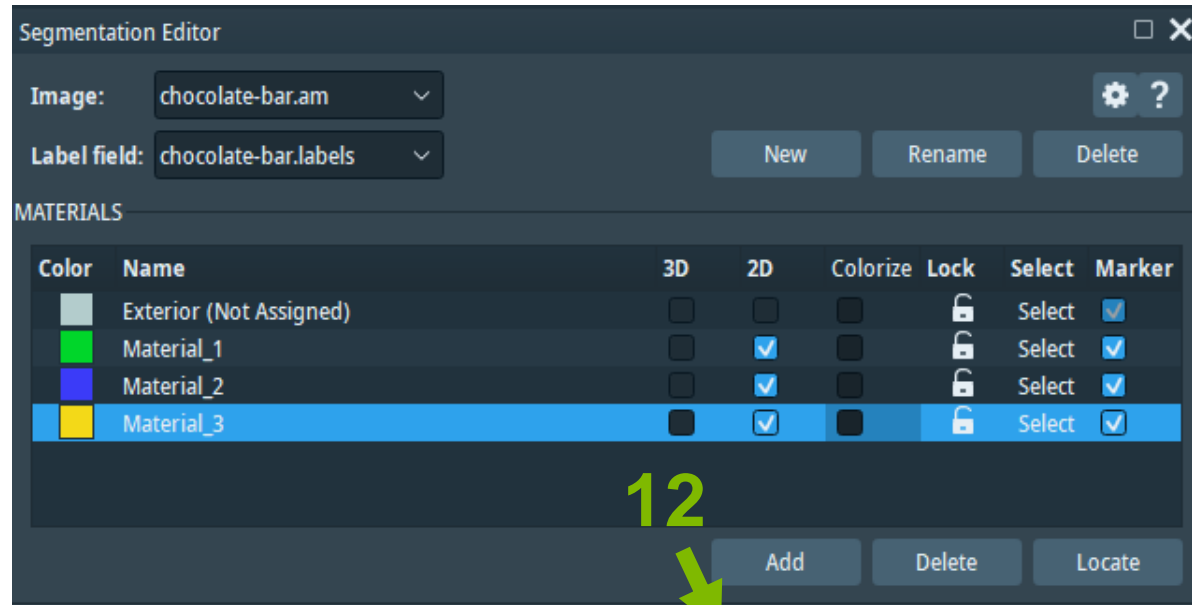


Image segmentation: Marker-based Watershed

The screenshot displays the ThermoFisher Segmentation Editor interface. The main window shows a 2D XY view of a chocolate bar cross-section with a segmented mask. The mask is composed of three distinct regions: a dark outer shell, a light-colored interior, and a darker central rectangular area. The software interface includes a menu bar at the top, a toolbar, and several panels on the left side.

Segmentation Editor Panel:

- Image:** chocolate-bar.am
- Label field:** chocolate-bar2.labels (indicated by a green arrow and the number 15)
- MATERIALS Table:**

Color	Name	3D	2D	Colorize	Lock	Select	marker
Grey	Exterior (Not Assigned)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select	<input checked="" type="checkbox"/>
Green	Material_1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select	<input checked="" type="checkbox"/>
Blue	Material_2	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select	<input checked="" type="checkbox"/>
Yellow	Material_3	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Select	<input checked="" type="checkbox"/>

DISPLAY CONTROL Panel:

- 2D:** 0, 1388, Edit
- 3D:** 478, 1910, Edit, Option
- Crosshairs, Slices, Volume rendering

SELECTION Panel:

- Volume, Current slice, Show in 3D
- No selection
- Landscape image: chocolate-bar.am, Create a new gradient image
- Markers: Selected materials, Select all, Deselect all
- Output catchment basins: separated, side-by-side
- Apply and create a new label field

Views:

- XY View:** Top-left, shows the 2D cross-section with a segmented mask. A green arrow points from the 'Material_1' row in the materials table to the light-colored interior region.
- YZ View:** Top-right, shows a side view of the chocolate bar with a segmented mask. A green arrow points from the 'Material_1' row in the materials table to the light-colored interior region.
- XZ View:** Bottom-left, shows a front view of the chocolate bar with a segmented mask. A green arrow points from the 'Material_1' row in the materials table to the light-colored interior region.
- 3D View:** Bottom-right, shows a 3D perspective view of the segmented chocolate bar. The interior is colored green, the outer shell is blue, and the central area is yellow.

Image segmentation: Marker-based Watershed

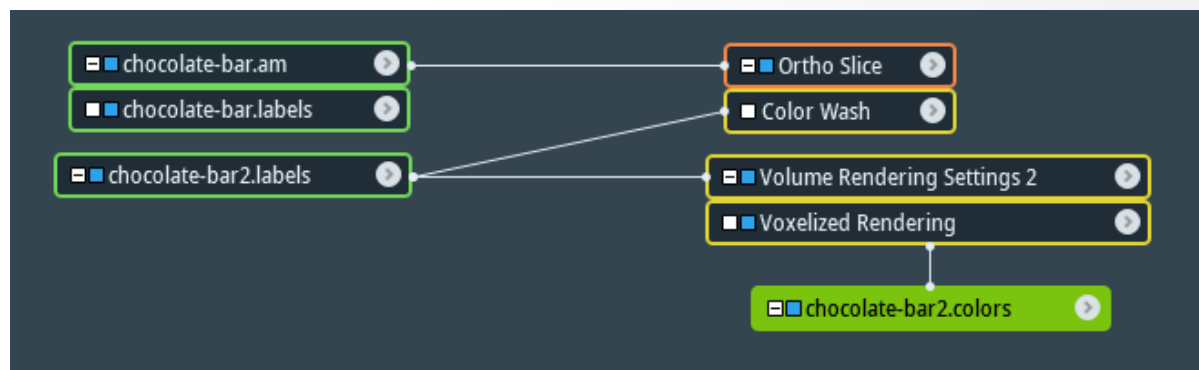
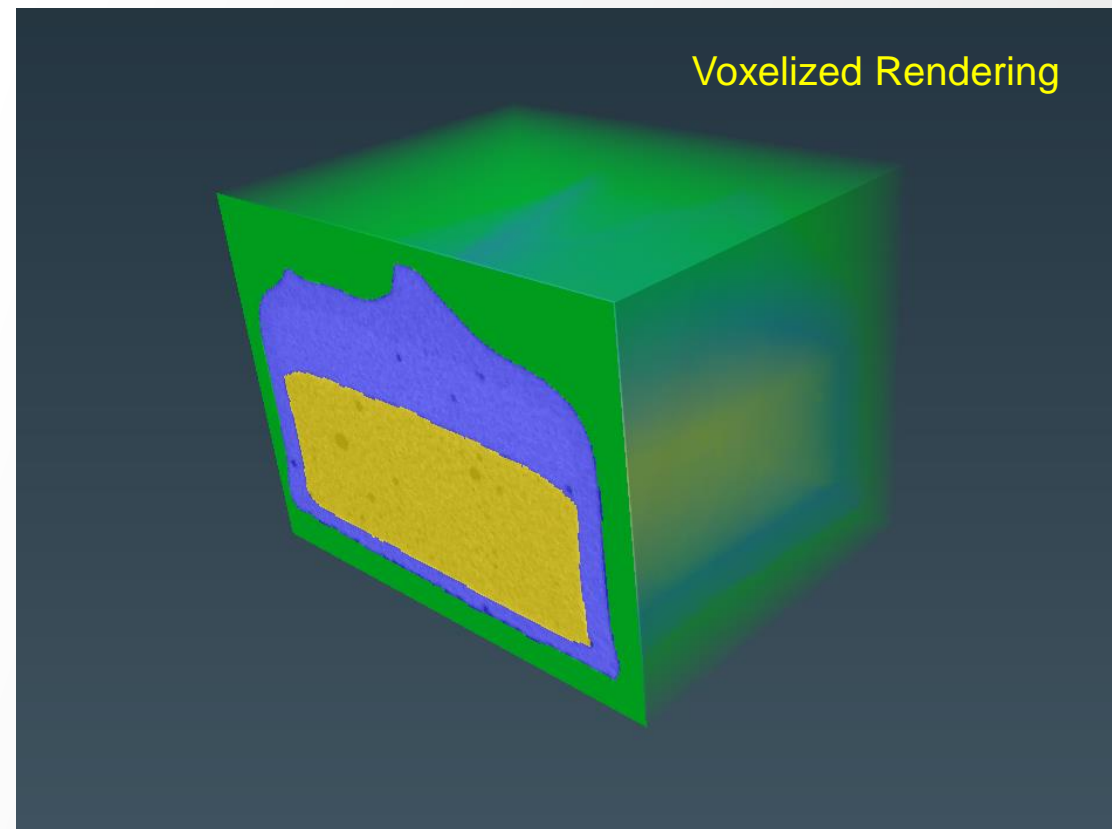
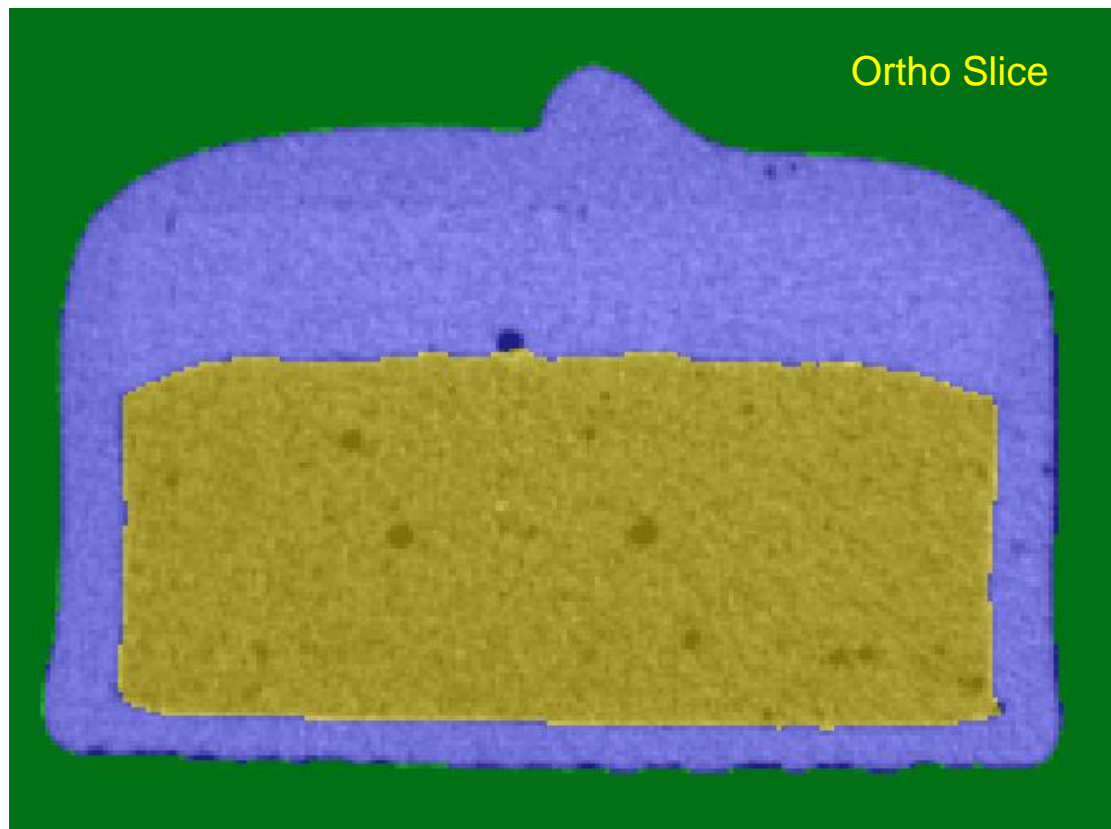
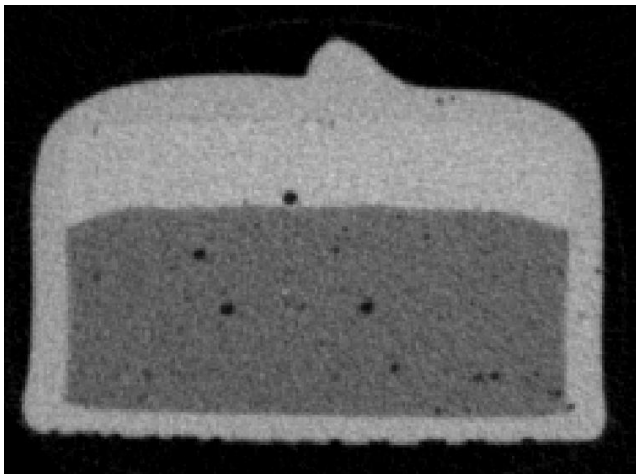


Image segmentation: Watershed Segmentation Wizard



- Define markers for phases via thresholding
- Mask out regions with high gradient magnitude
- Expand markers with watershed

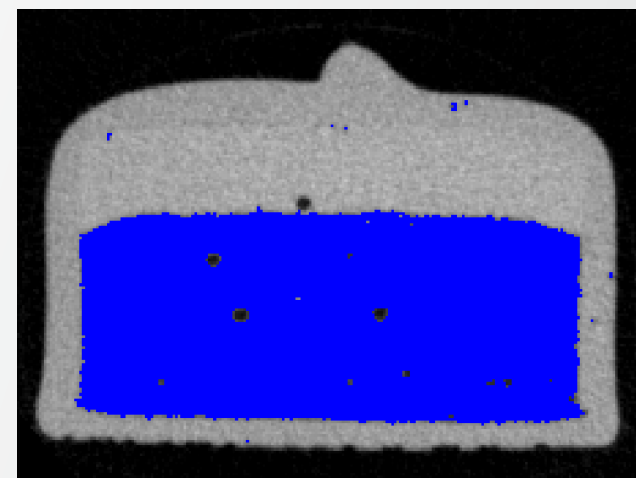
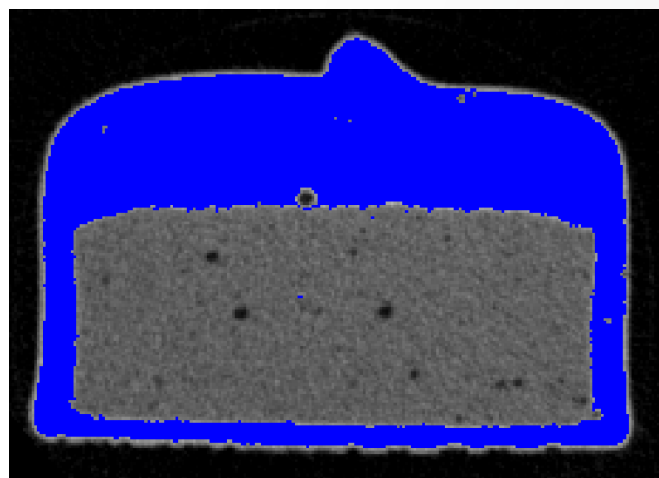
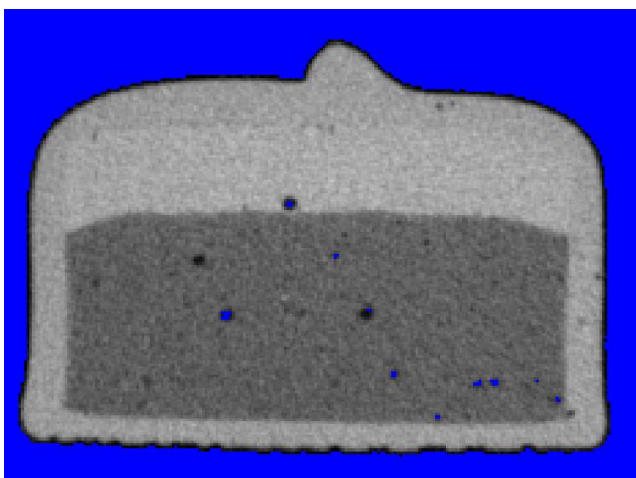
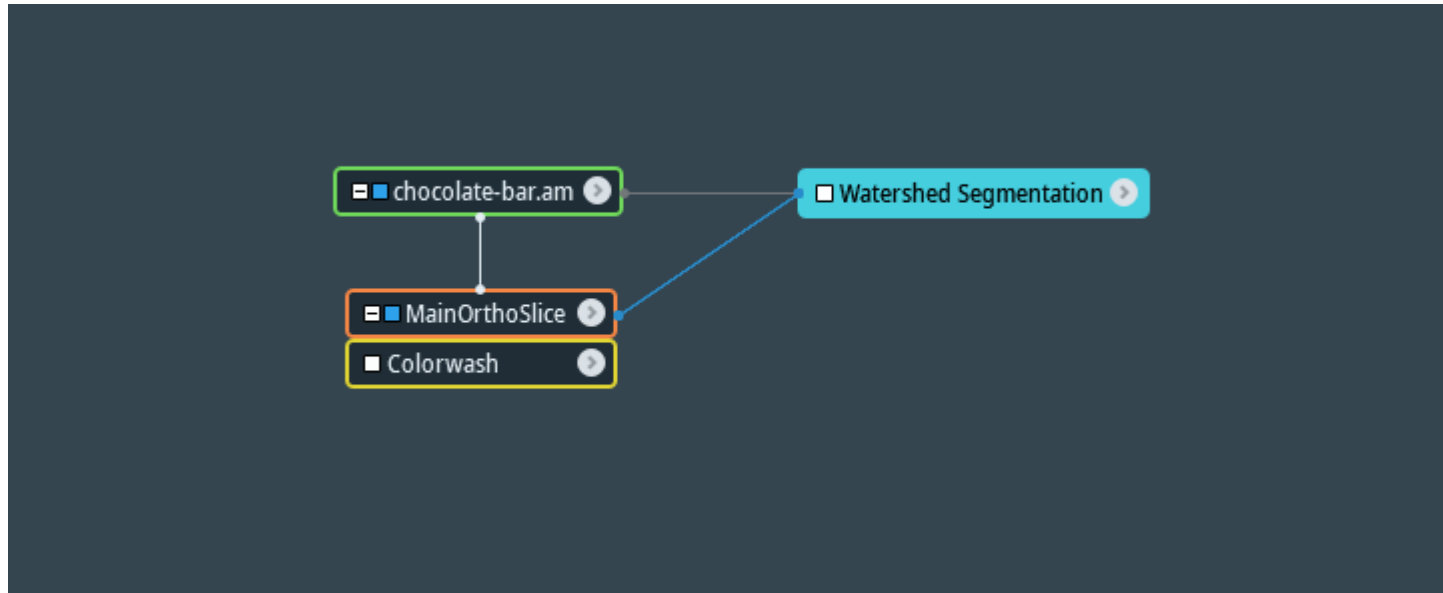


Image segmentation: Watershed Segmentation wizard



Properties

Watershed Segmentation

Data: chocolate-bar.am →

Restart -objects/WatershedSegmentation2.scro Browse

Slice Number: ◀ 147 ▶ ...

Slice Orientation: xy xz yz

Info: Step 1 of 3: Give Number of Phases

Action: Back Skip Apply

Number of Phases: 3

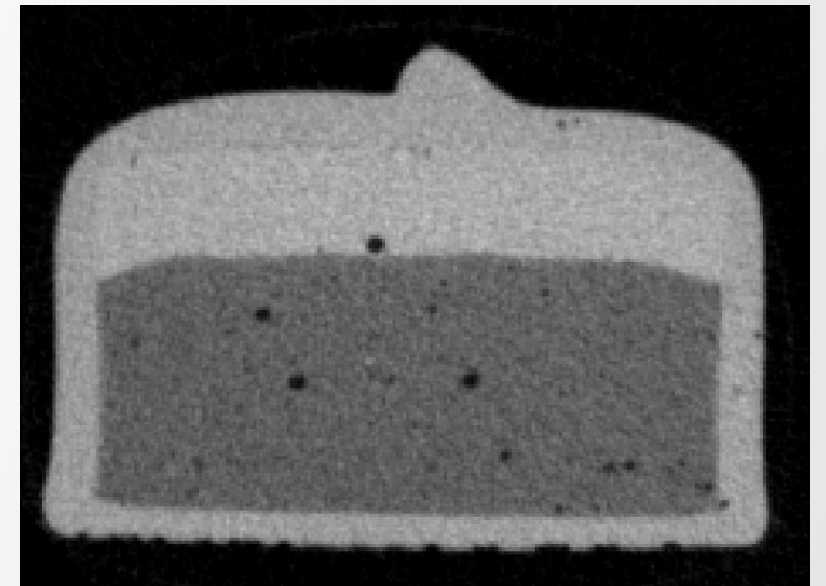


Image segmentation: Watershed Segmentation wizard

Properties

Watershed Segmentation

Data: chocolate-bar.am

Gradient: NO SOURCE

Restart -objects/WatershedSegmentation2.scro Browse

Slice Number: 147

Slice Orientation: xy xz yz

Info: Step 2 of 7: Compute Gradient Magnitude

Action: Back Skip Apply

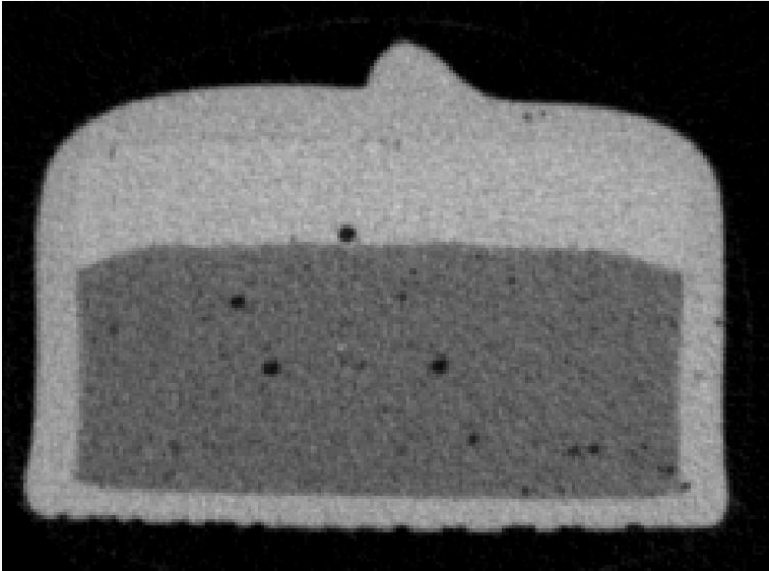


Image segmentation: Watershed Segmentation wizard

Properties

Watershed Segmentation

Data: chocolate-bar.am

Restart -objects/WatershedSegmentation2.scro Browse

Slice Number: 147

Slice Orientation: xy xz yz

Info: Step 3 of 7: Threshold Gradient Magnitude

Action: Back Skip Apply

Auto:

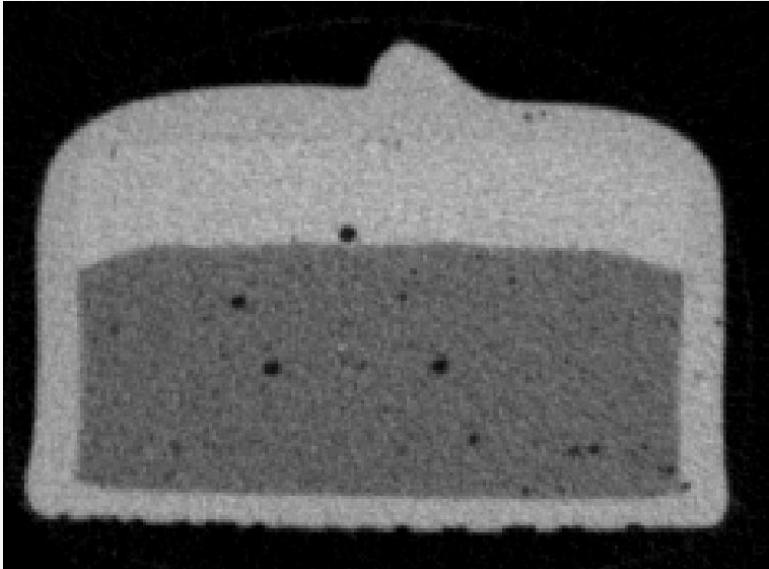


Image segmentation: Watershed Segmentation wizard

Properties

Watershed Segmentation

Data: chocolate-bar.am

Phase 0: NO SOURCE

Restart -objects/WatershedSegmentation2.scro Browse

Slice Number: 147

Slice Orientation: xy xz yz

Info: Step 4 of 7: Threshold Phase 0 or give phase directly

Action: Back Skip Apply

Min-Max Phase 0: 0 410

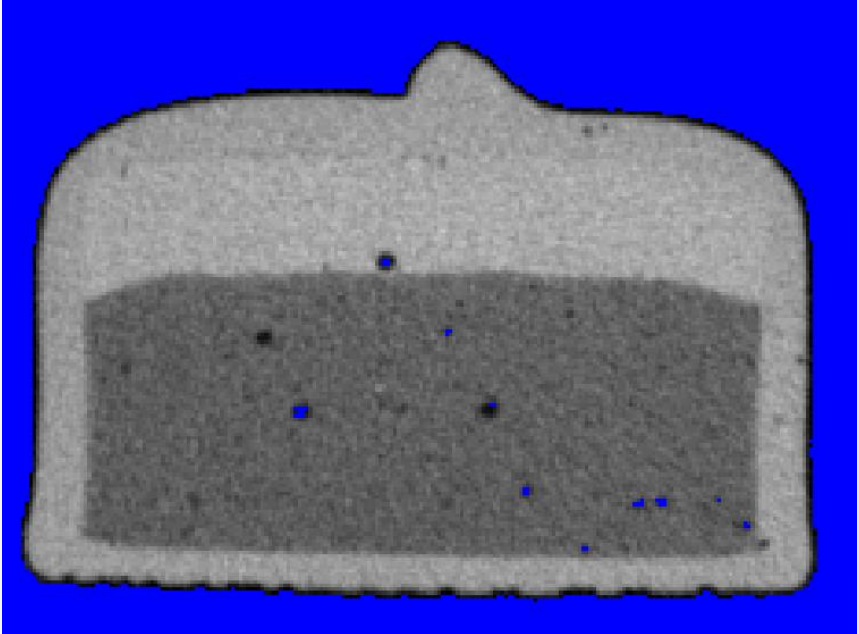


Image segmentation: Watershed Segmentation wizard

Properties

Watershed Segmentation

Data: chocolate-bar.am

Phase 1: NO SOURCE

Restart -objects/WatershedSegmentation2.scro Browse

Slice Number: 147

Slice Orientation: xy xz yz

Info: Step 5 of 7: Threshold Phase 1 or give phase directly

Action: Back Skip Apply

Min-Max Phase 1: 910 1910

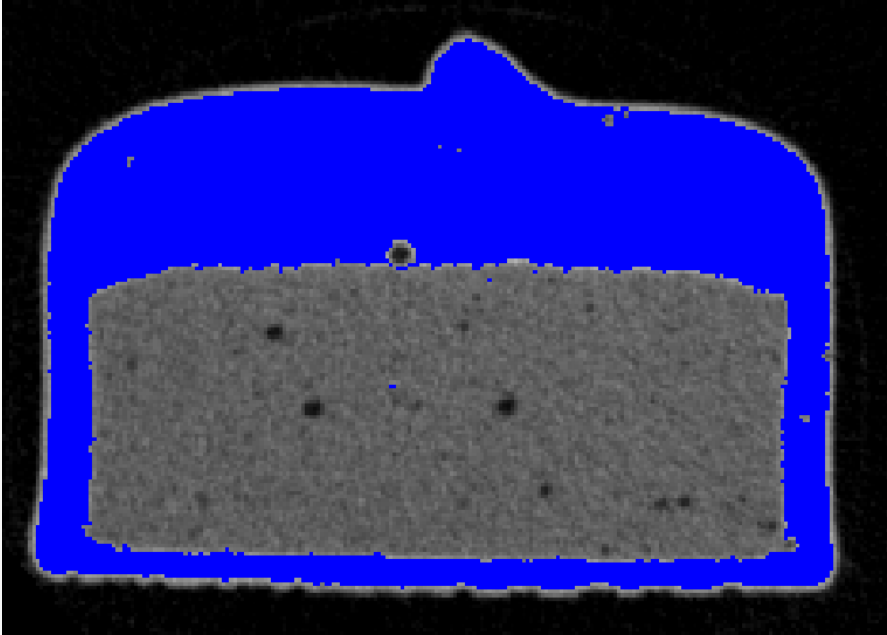


Image segmentation: Watershed Segmentation wizard

Properties

Watershed Segmentation

Data: chocolate-bar.am

Phase 2: NO SOURCE

Restart -objects/WatershedSegmentation2.scro Browse

Slice Number: 147

Slice Orientation: xy xz yz

Info: Step 6 of 7: Threshold Phase 2 or give phase directly

Action: Back Skip Apply

Min-Max Phase 2: 410 910

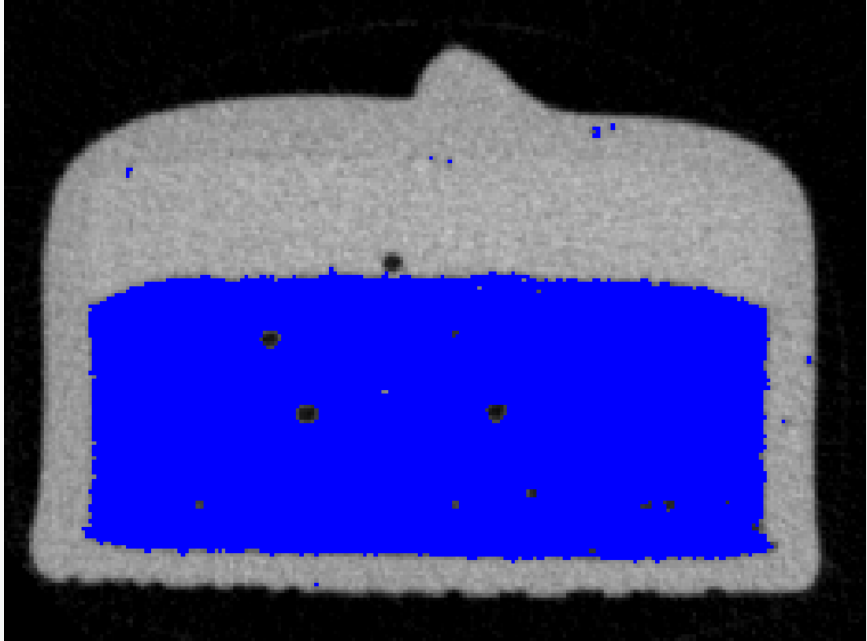


Image segmentation: Watershed Segmentation wizard

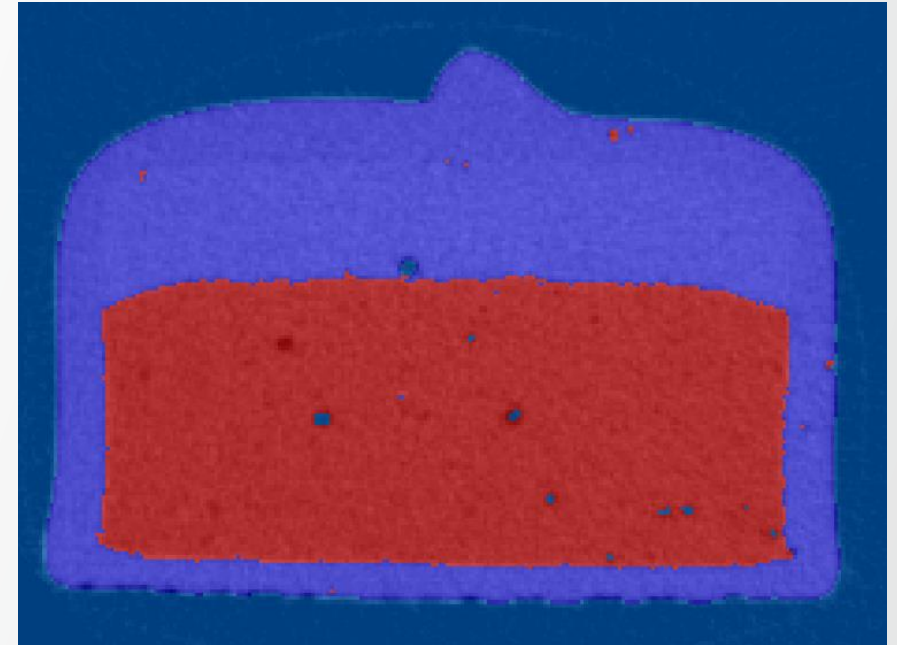
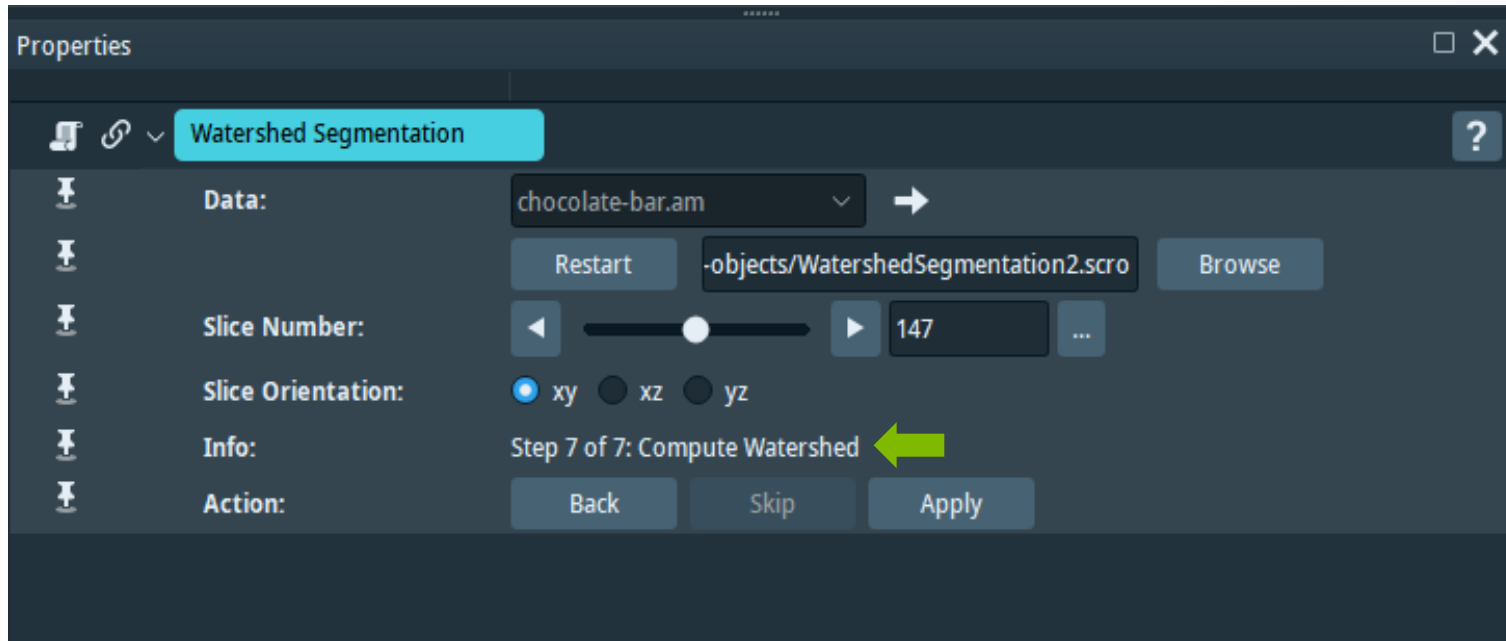


Image segmentation: Watershed Segmentation wizard

The screenshot displays the Watershed Segmentation wizard interface. At the top, a workflow diagram shows the process flow: 'basins*' (green box) receives input from 'chocolate-bar.am' (green box) and 'MainOrthoSlice' (orange box). 'MainOrthoSlice' also receives input from 'Colorwash' (yellow box). Both 'chocolate-bar.am' and 'MainOrthoSlice' feed into the 'Watershed Segmentation' step (cyan box). Below the diagram is the 'Properties' panel for the 'Watershed Segmentation' step. The 'Data' field is set to 'chocolate-bar.am'. The 'Slice Number' is 147. The 'Slice Orientation' is set to 'xy'. The 'Info' section shows 'End of steps' with a green arrow pointing to the left. The 'Action' section includes 'Back', 'Skip', and 'Apply' buttons.

basins* chocolate-bar.am Watershed Segmentation
MainOrthoSlice Colorwash

Properties

Watershed Segmentation

Data: chocolate-bar.am

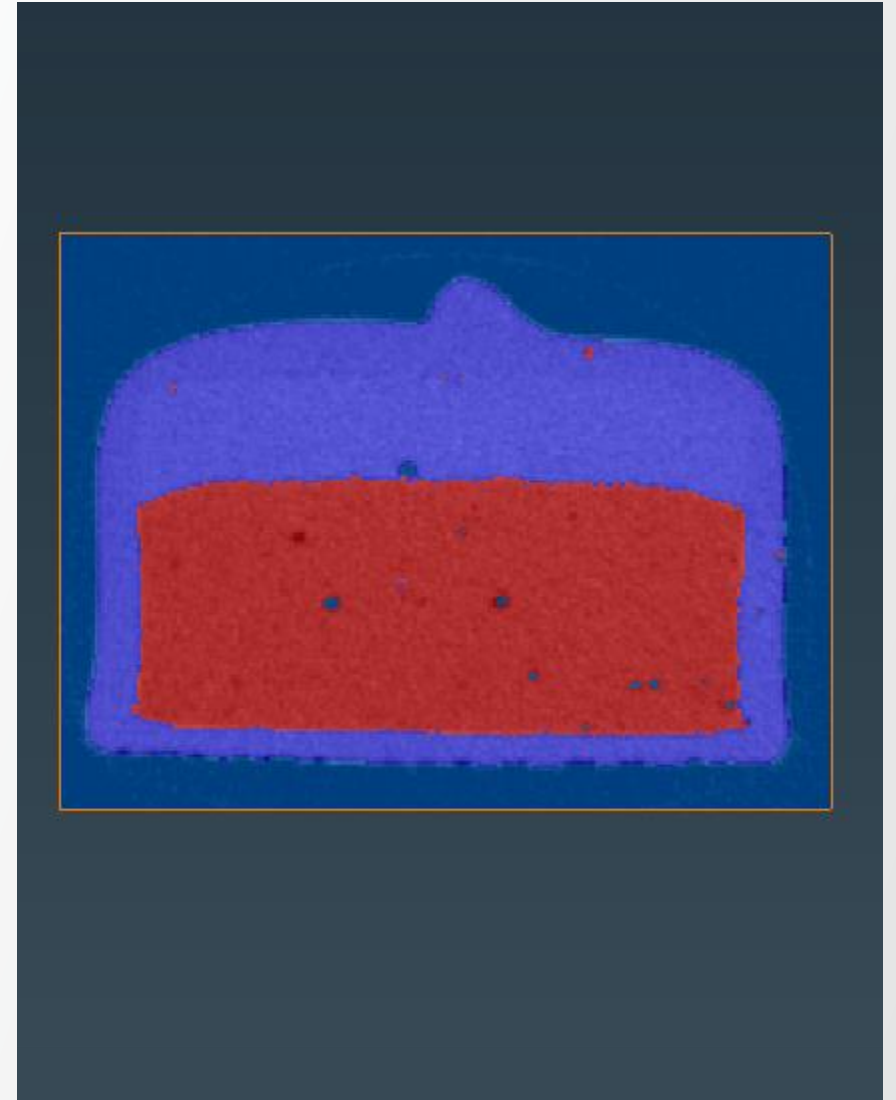
Restart -objects/WatershedSegmentation2.scro Browse

Slice Number: 147

Slice Orientation: xy xz yz

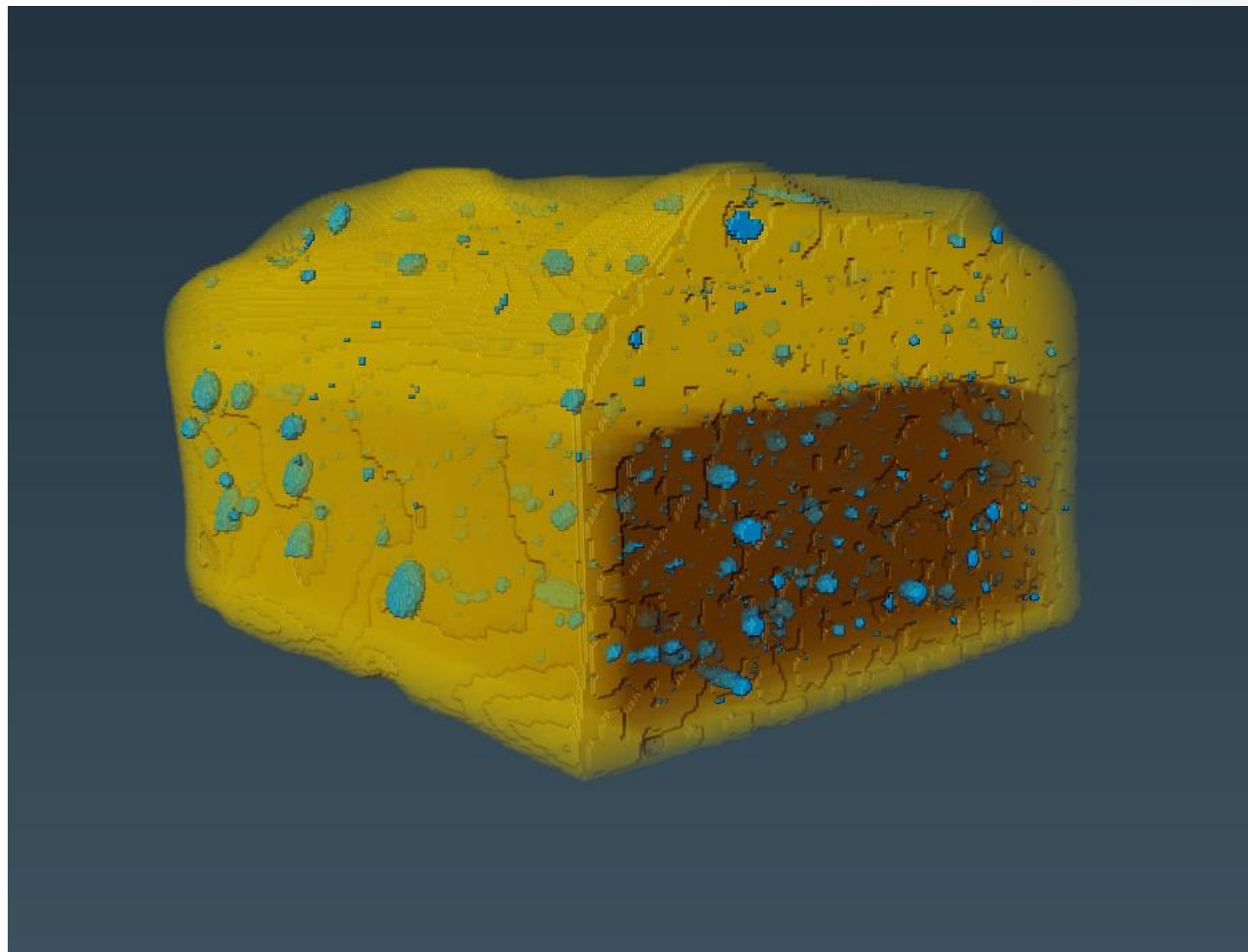
Info: End of steps

Action: Back Skip Apply



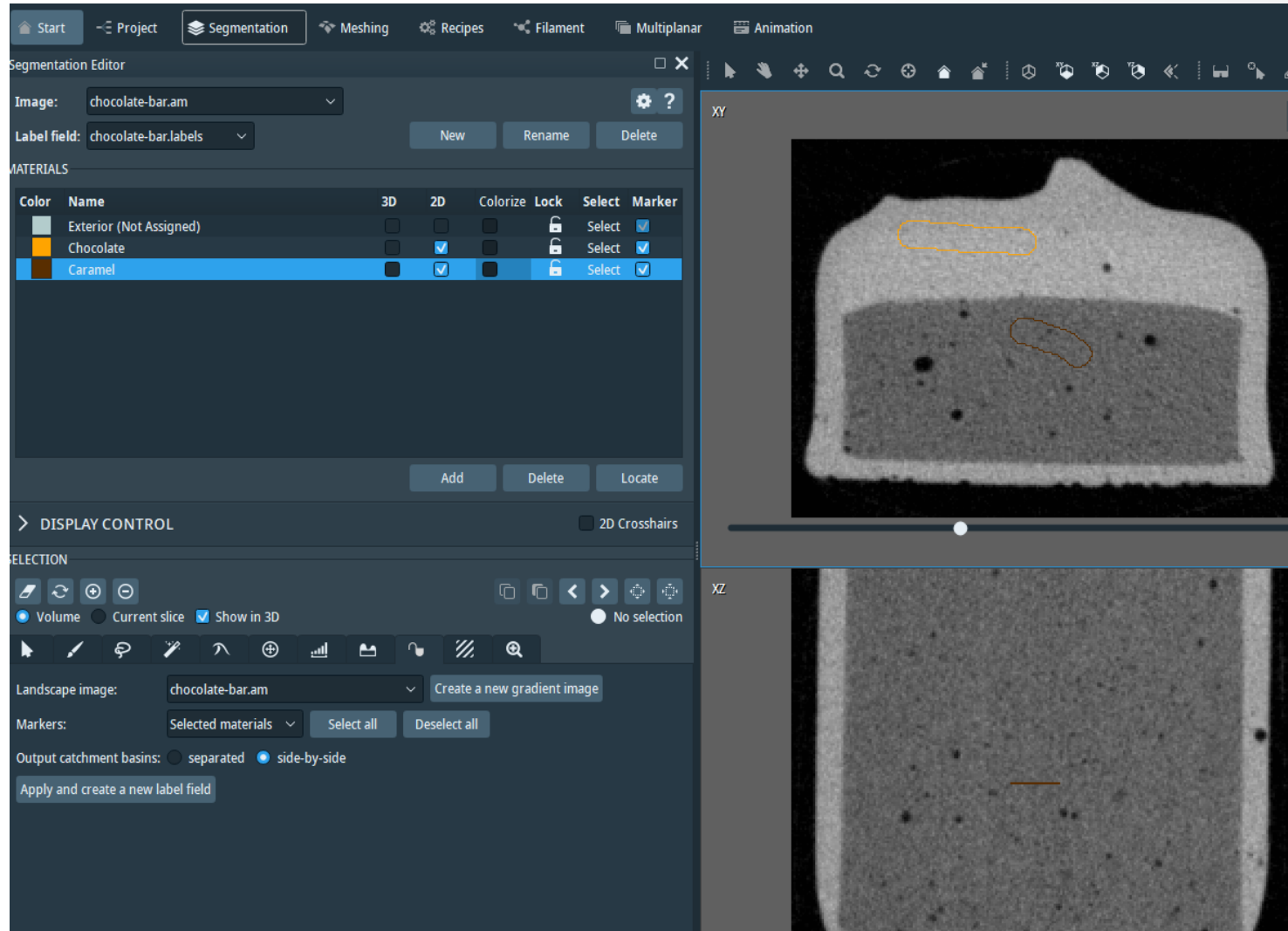
Watershed in Segmentation Editor: exercise

Multi-phase segmentation of chocolate bar



Watershed in Segmentation Editor: exercise

Solution



Watershed in Segmentation Editor: exercise

Solution

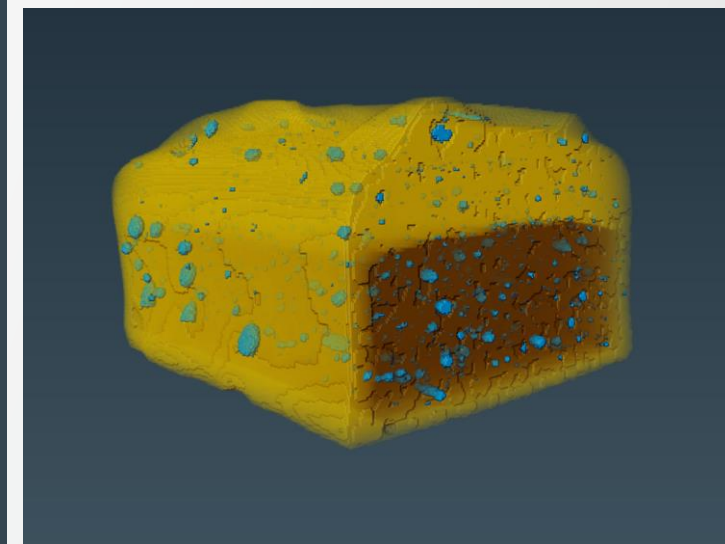
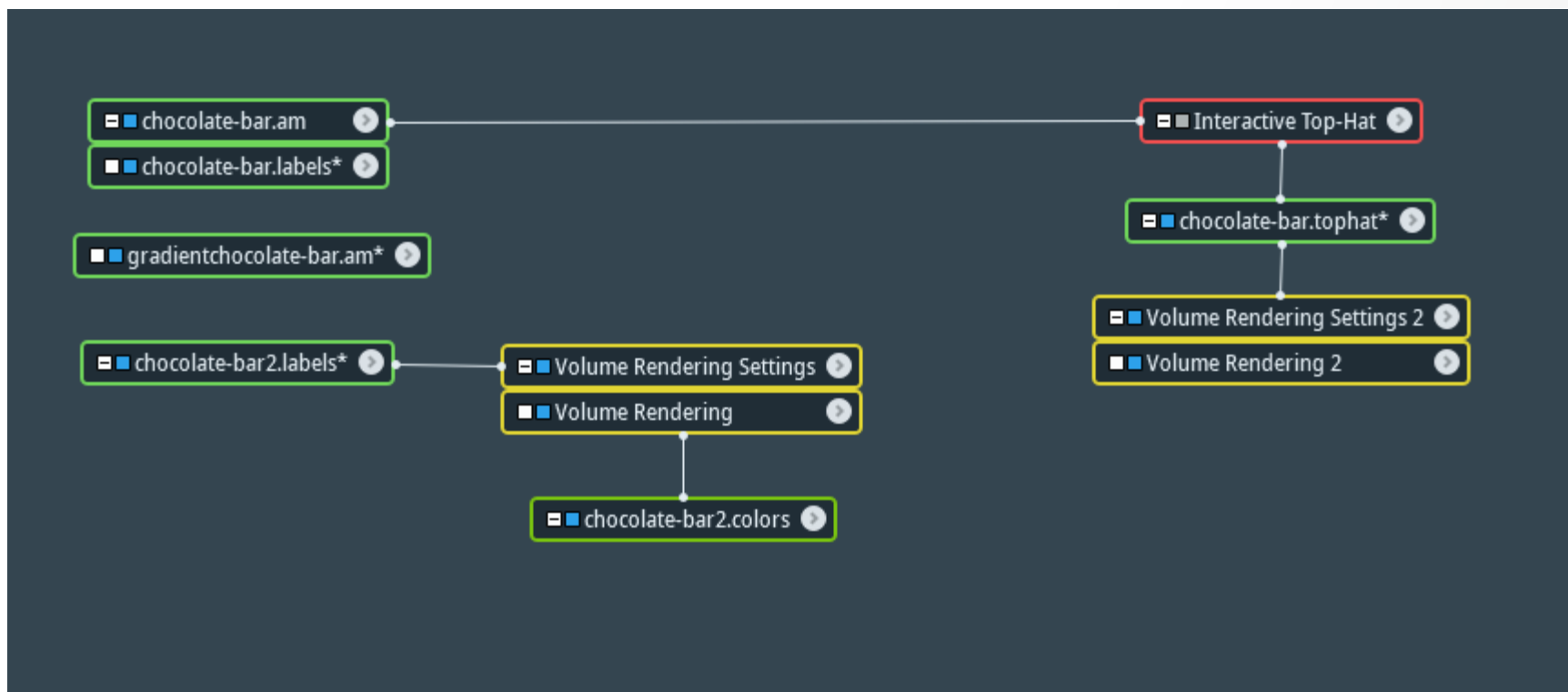


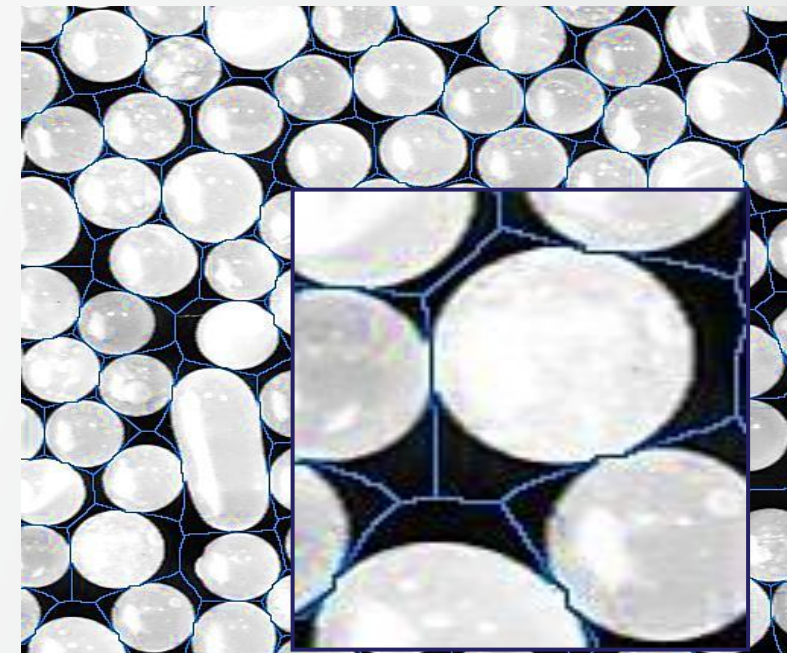
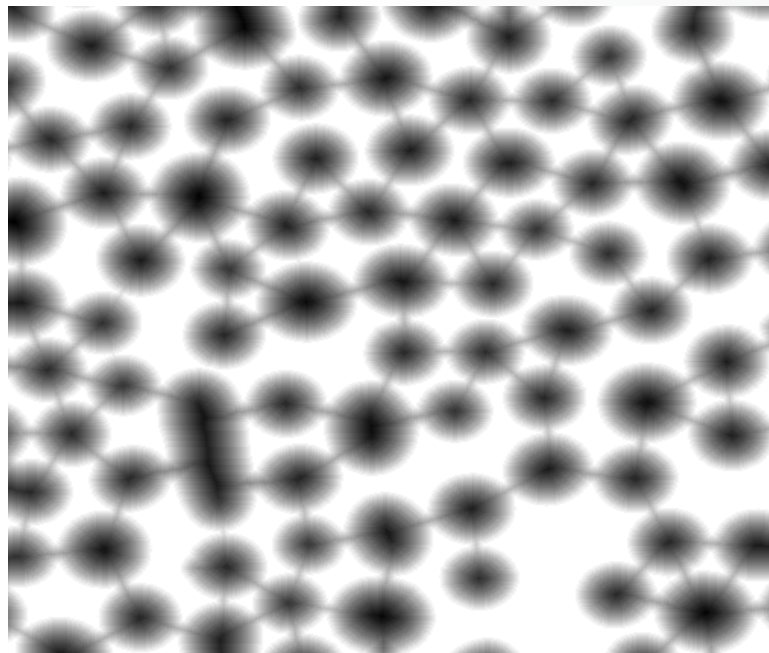
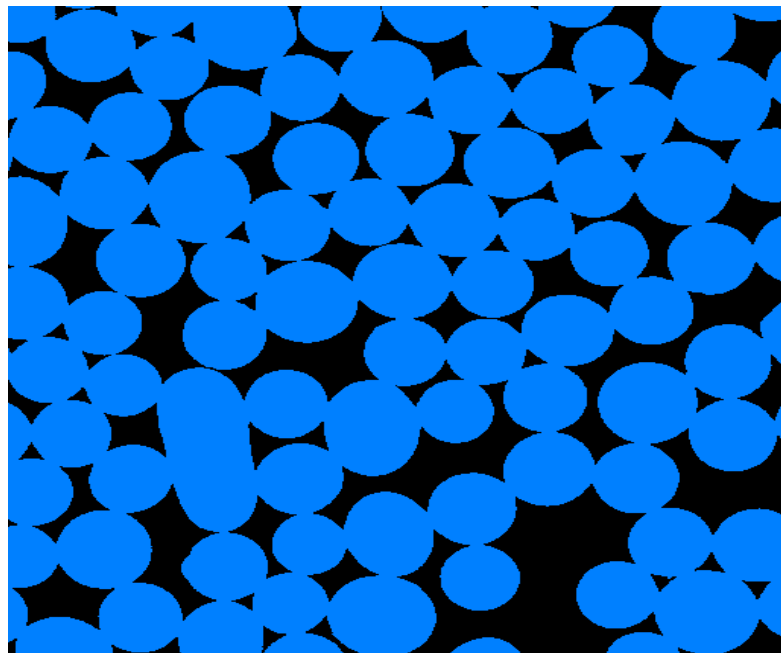
Image segmentation: post-processing

Segmentation post-processing: morphological filtering

- Binary mathematical morphology
 - Interactive Shrink & Grow in Segmentation Editor
 - **Opening** and **Closing**
- **Fill Holes**
- **Dilate + Fill Holes + Erode**: may close more open cavities/pores
- **Remove Small Spots**
- **Border Kill**: removes objects touching image bounding box

Segmentation post-processing: object separation

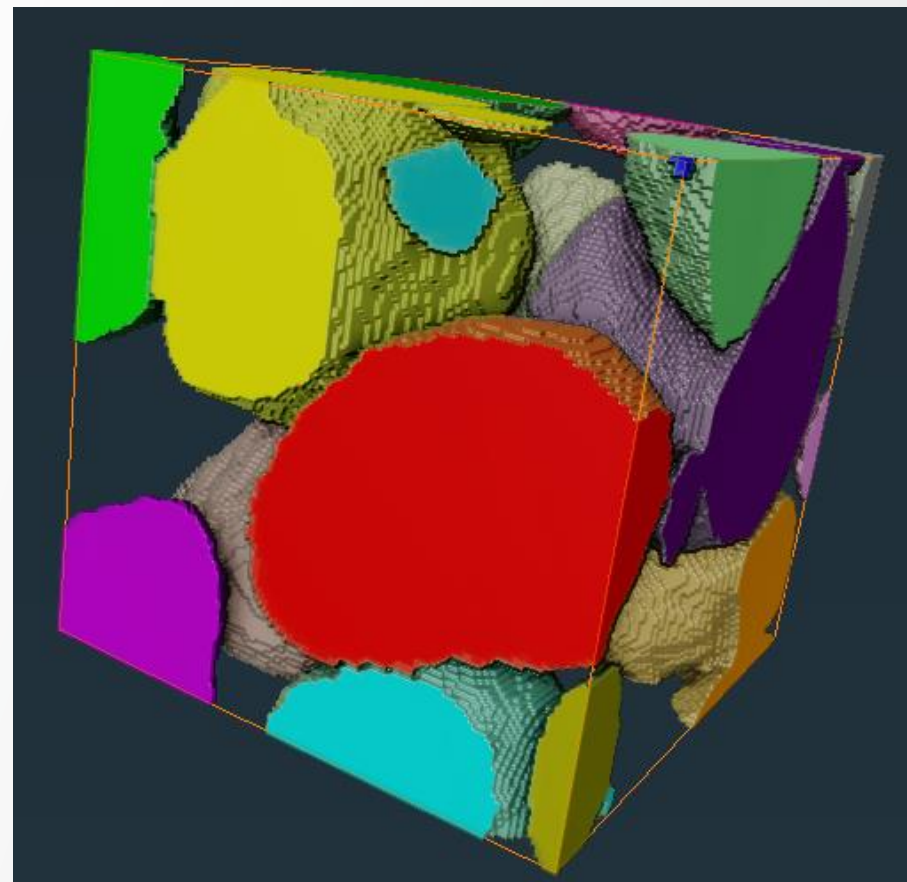
- **Separate Objects**
 - Smaller 'Extent' value means more separation
 - Criterion relates to convexity of the particles
 - See tutorial **“Separating, Measuring and Reconstructing -> Separation using Watershed step by step”**



Segmentation post-processing: exercise

Separate objects after sand-pack segmentation

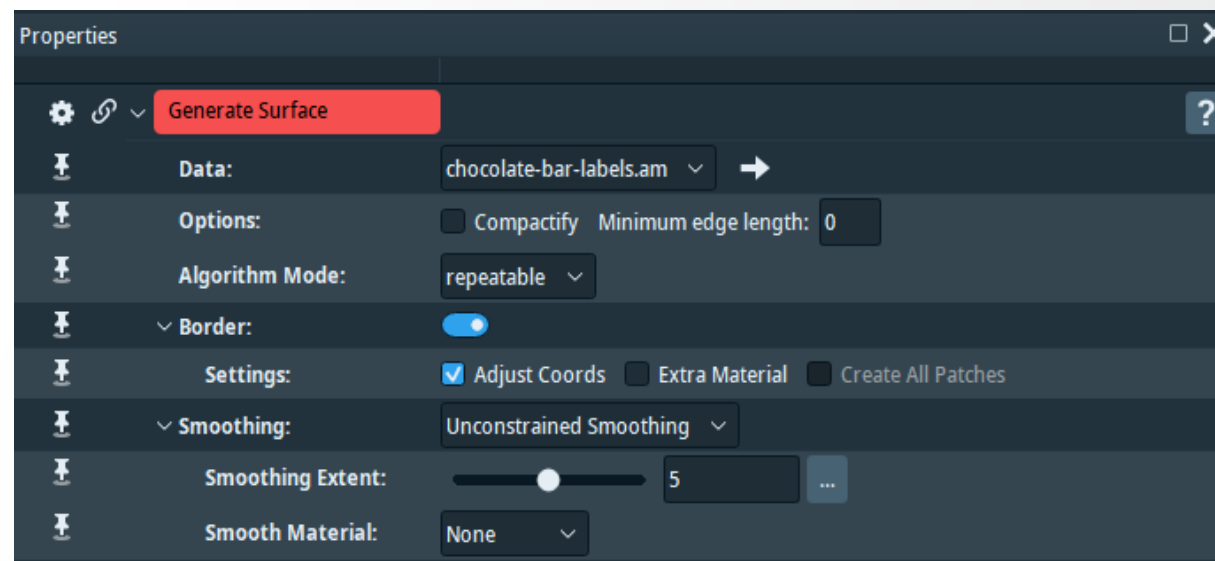
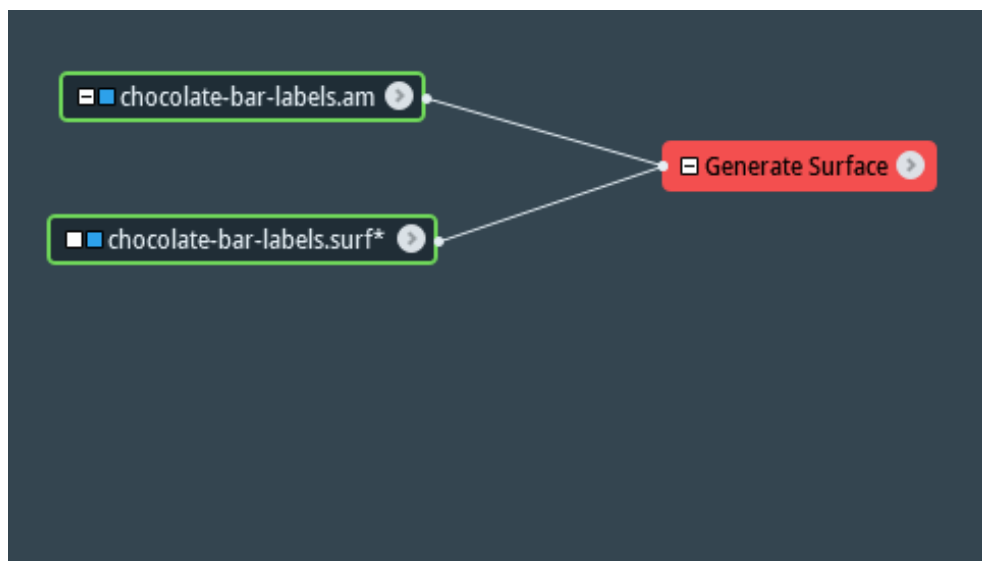
- Data to use is Data/Sandpack/SandPack128.am
- Follow steps given in tutorial “**Separating, Measuring and Reconstructing -> Separation using Watershed step by step**”



Surface generation

Surface reconstruction

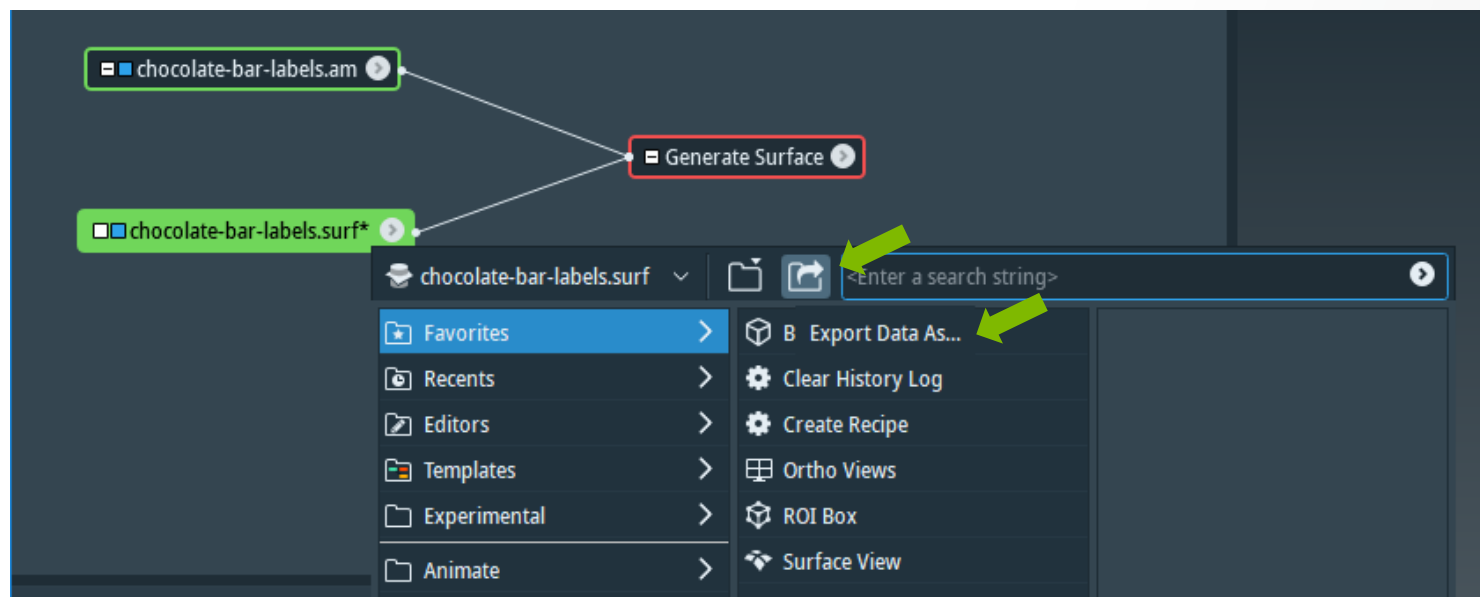
Open the label image `chocolate-bar-labels` (data>tutorials) then attach `Generate Surface` module to the label image. In the properties window, using the default parameters:



- **Data:** chocolate-bar-labels.am (label image)
- **Border Settings:** Adjust Coords
- **Algorithm Mode** : repeatable
- **Smoothing:** Unconstrained Smoothing (use None/Constrained smoothing to preserve thin structures)
- **Smoothing Extent:** 5

Surface data export

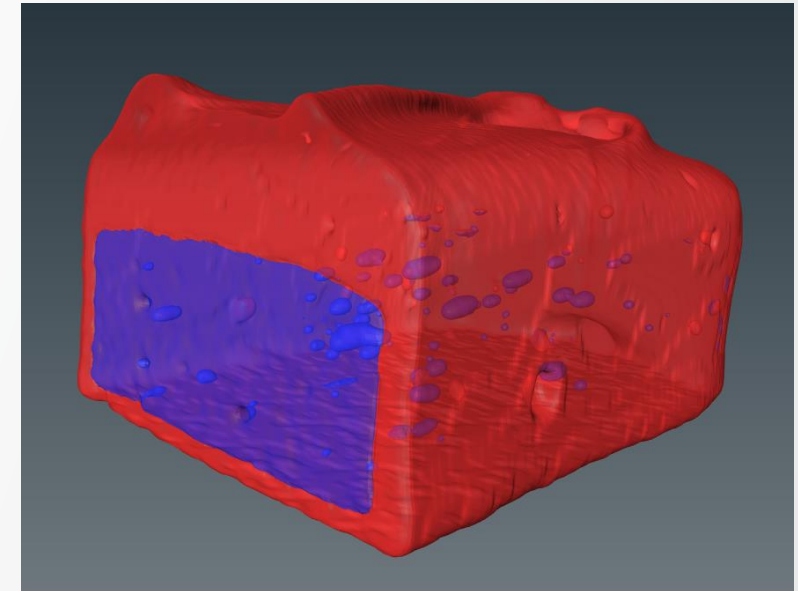
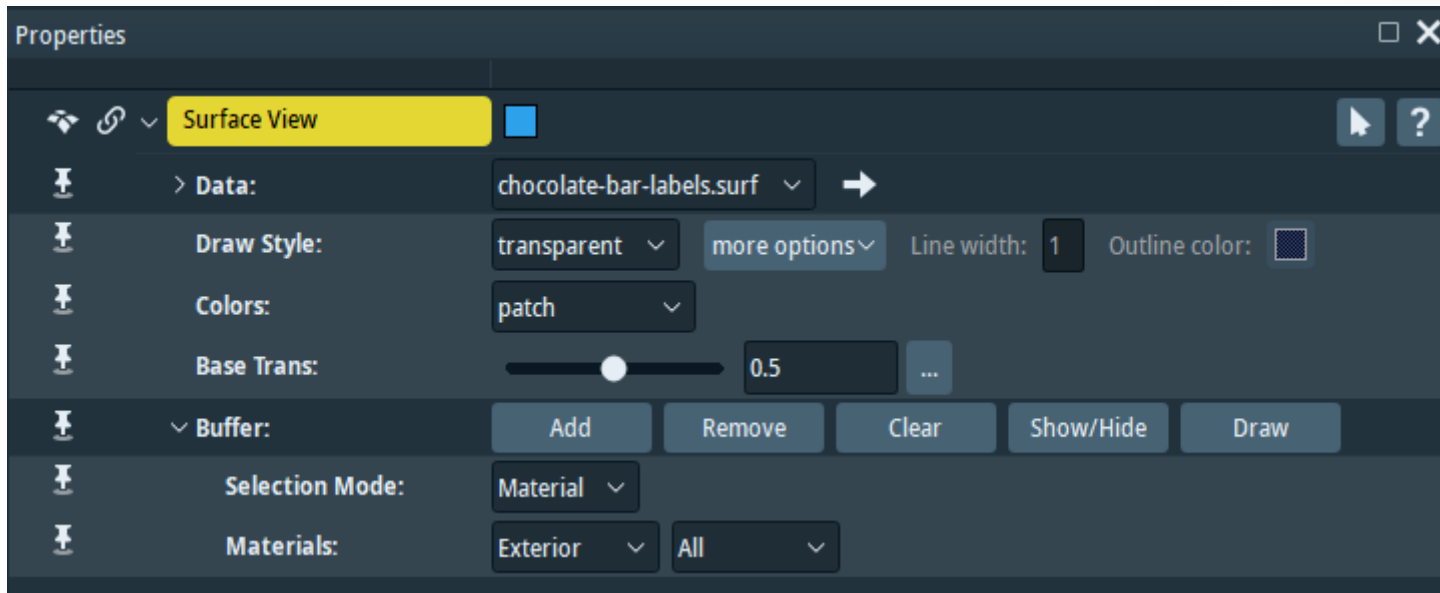
The result surface `chocolate-bar-labels.surf` can be exported by right click at the surface (or left click and then go to > File) and select **Export Data As** then select the format (e.g. `.stl` or `.obj`) to export.



- Open Inventor binary compressed (*.iv)
- Wavefront (*.obj)
- ABAQUS Input (*.inp)
- ANSYS Input (*.ans)
- AVS UCD ascii (*.inp)
- AVS UCD binary (*.inp)
- CGNS (*.cgns)
- COMSOL ascii (*.mphtxt)
- COMSOL binary (*.mphbin)
- DXF (*.dxf)
- Ensign Gold binary (*.case)
- FLUENT/UNS (*.cas)
- Hypermesh ascii (*.hmascii *.hm)
- MSC/NASTRAN Bulk Data (*.bdf)
- Matlab m-file (*.m)
- SDRC/IDEAS Universal (*.unv)
- STL ascii (*.stl)**
- STL binary Big Endian (*.stl)
- STL binary Little Endian (*.stl)
- Stanford PLY (*.ply)
- Tecplot 10 binary (*.plt)
- Avizo Binary Surface (*.am)

Surface view

Attach **Surface View** to the **chocolate-bar-labels.surf** to visualize the surface.

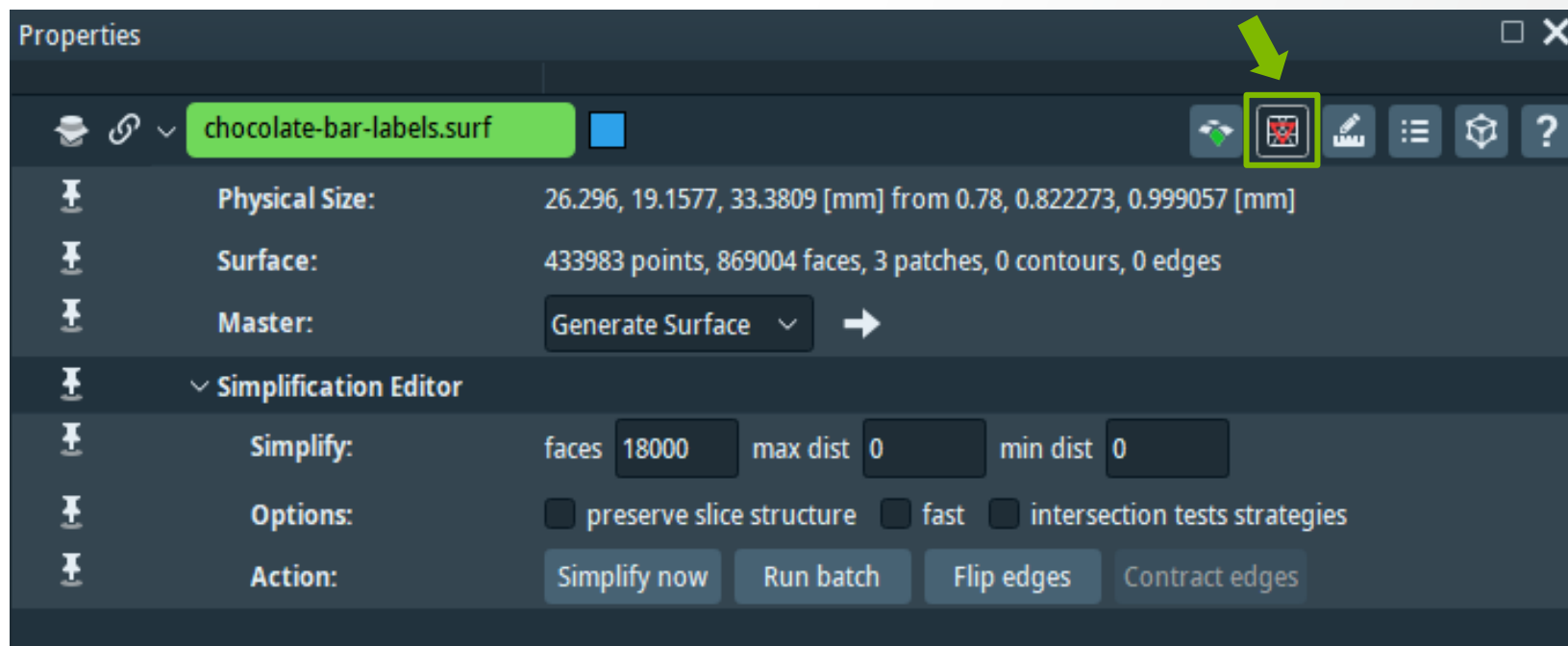


- **Data:** chocolate-bar-labels.surf
- **Draw Style:** Transparent
- **Colors:** patch
- **Base Trans:** 0.5

Surface View usage, tips & tricks: <https://youtu.be/zXq3A4bKcFg>

Surface simplification

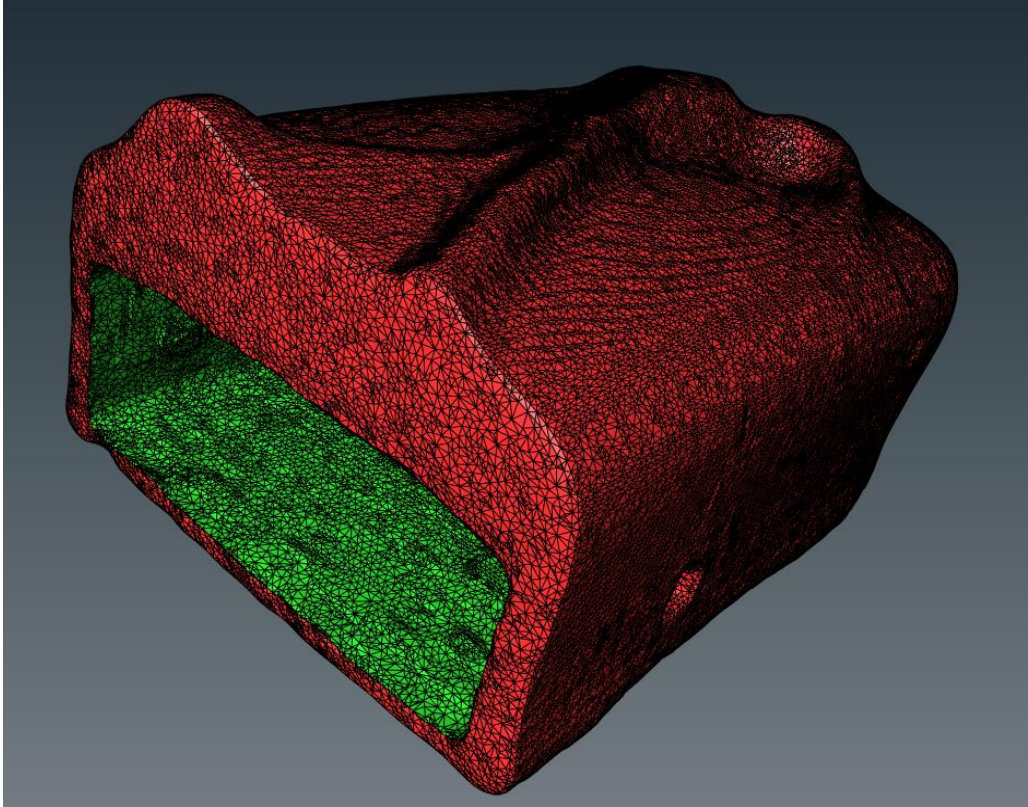
Activate **Simplification Editor** in the properties port of **chocolate-bar-labels.surf**.



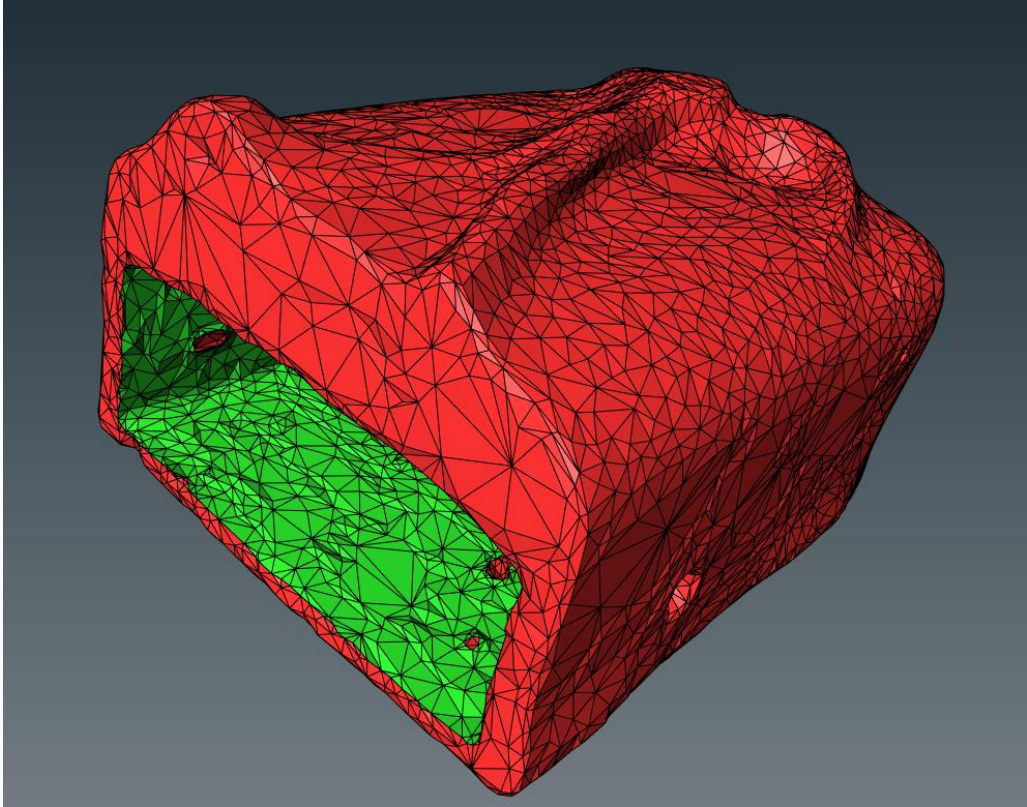
Simplification Editor

- **Simplify:** faces 18000 (0 max & min dist)
- **Action:** Simplify now

Surface simplification example



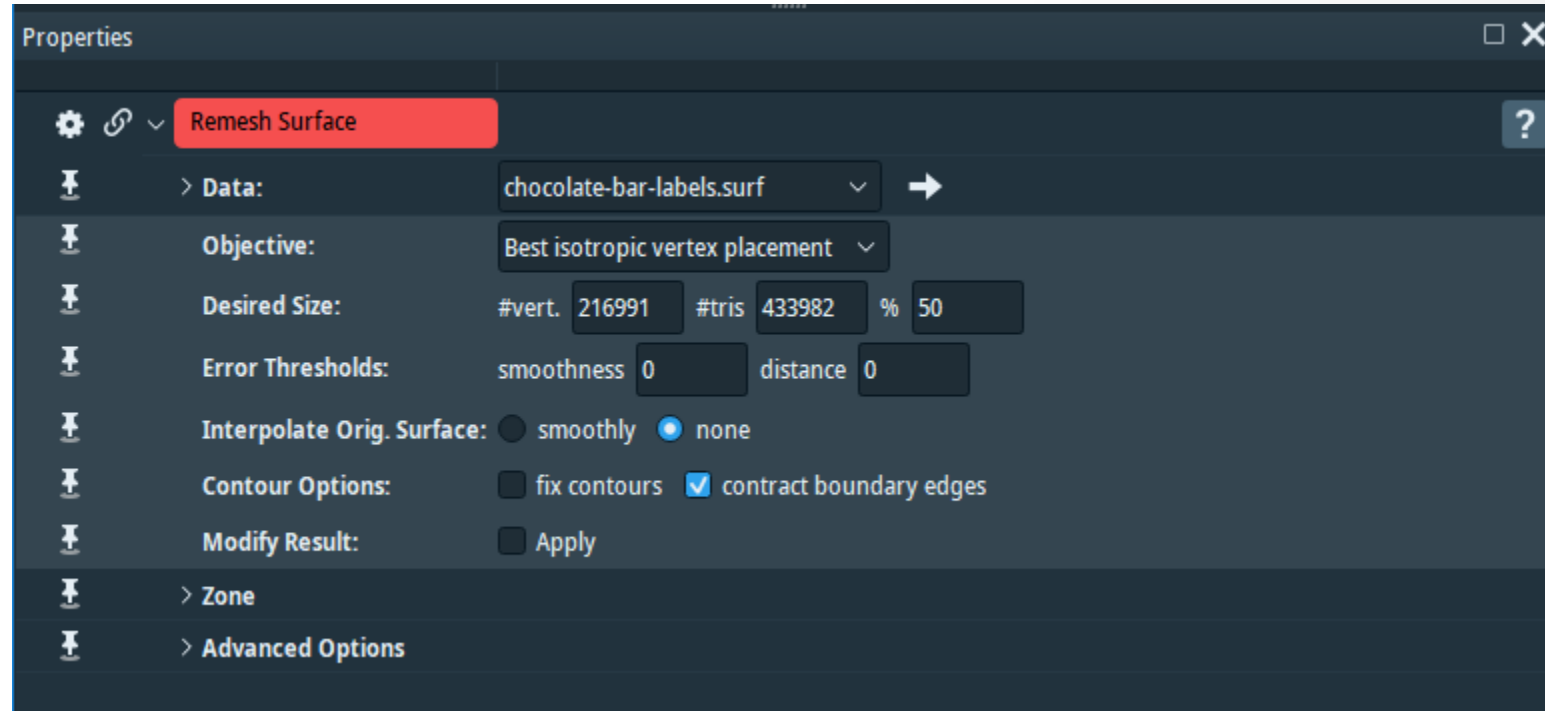
180000 faces



18000 faces

Surface remeshing

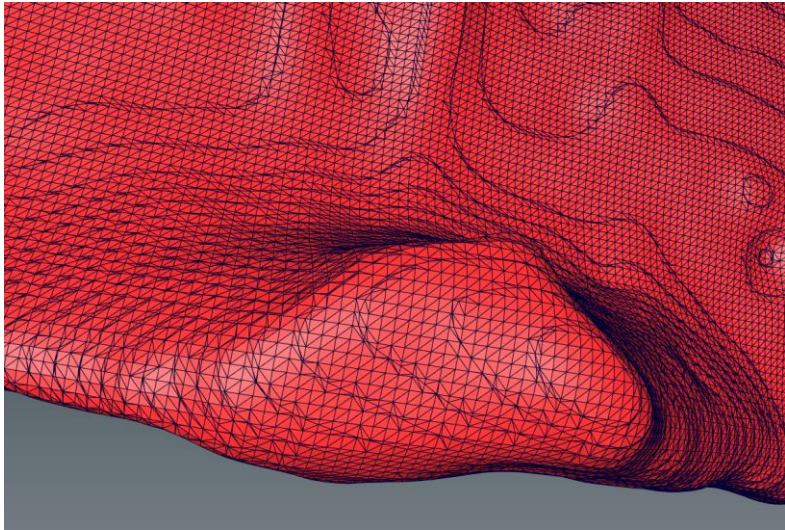
After reconstruction, the surface can be coarse: for refining, remeshing is necessary. Attach **Remesh Surface** module to the **chocolate-bar-labels.surf**.



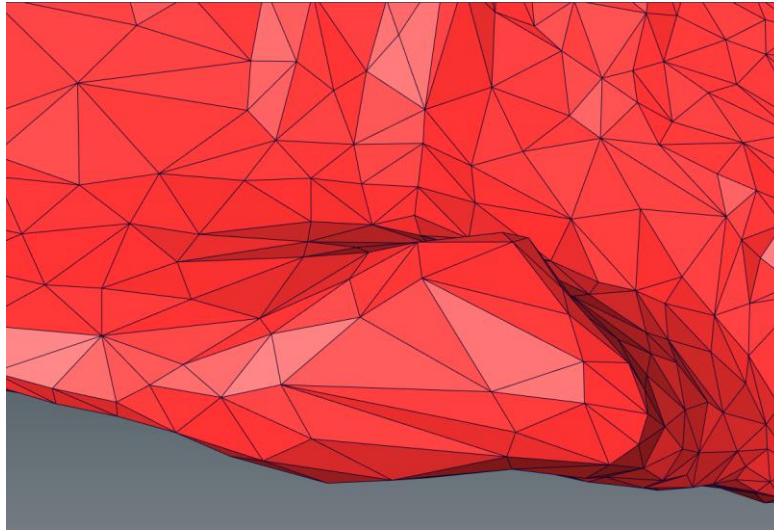
- **Data:** chocolate-bar-labels.surf
- **Objective:** Best isotropic vertex placement
- **Desired Size:** #vertex = 216991, #tris = 433982, % = 50
- **Interpolate Original Surface:** none
- **Contour Options:** contract boundary edges

Surface remeshing

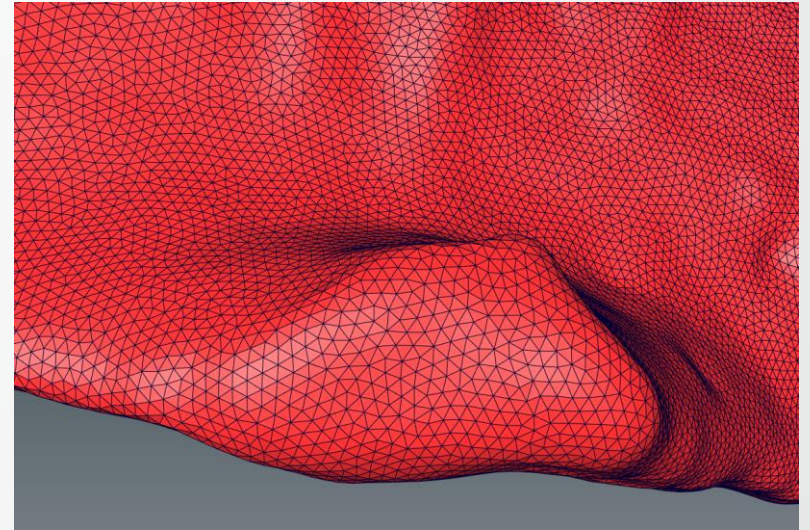
Dataset: *Chocolate-bar-labels.surf*



Original surface



After simplification

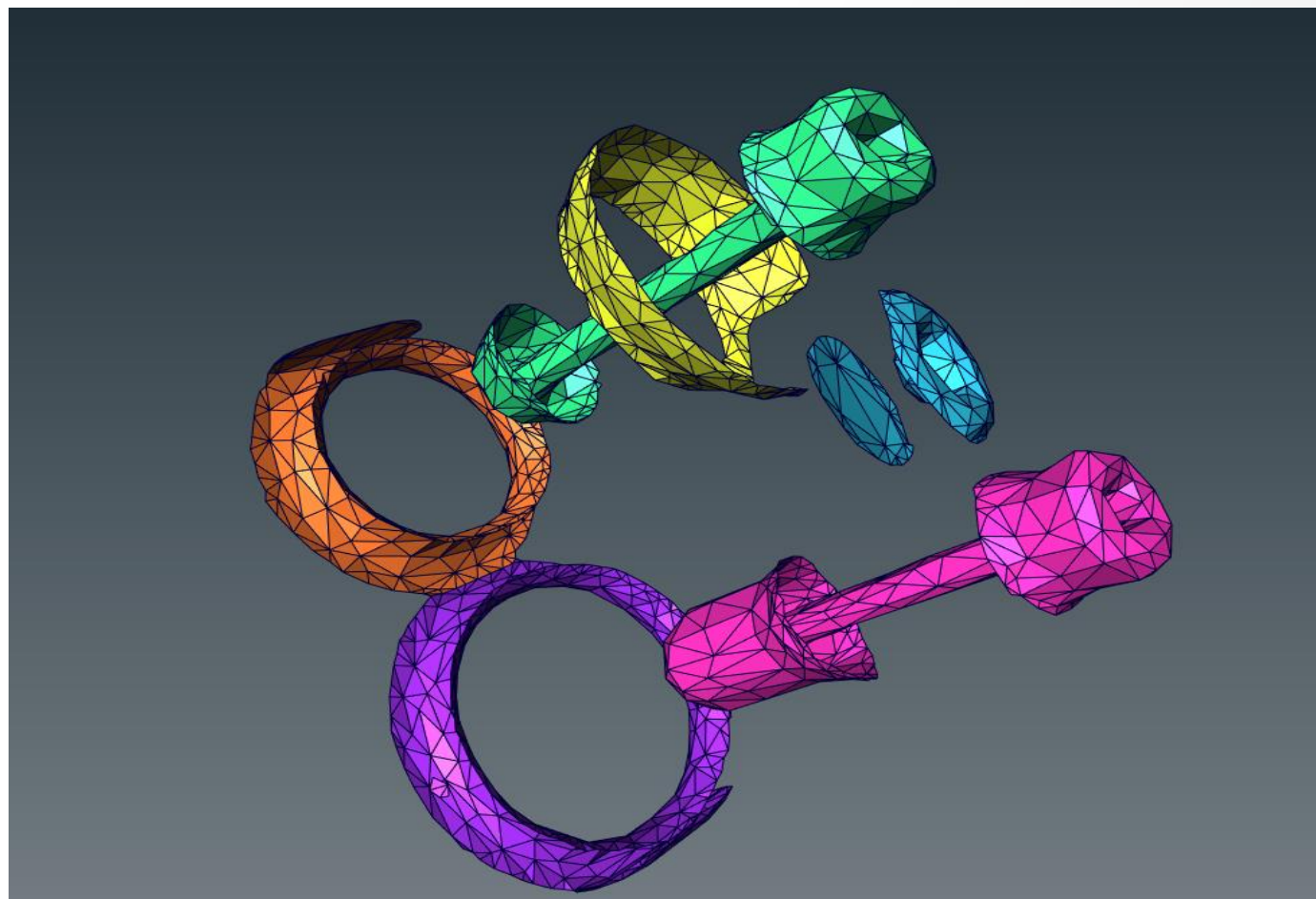


After remeshing

Surface view: exercise

Tuning Surface View module

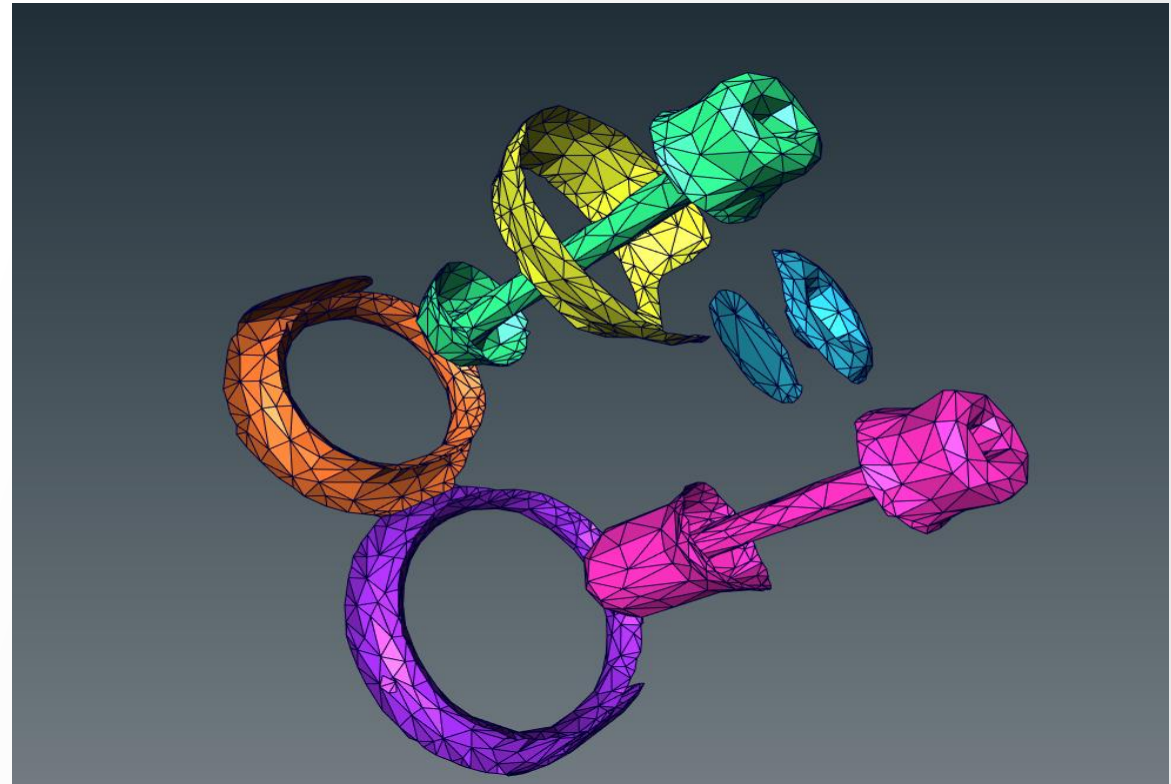
Load *motor.labels* (data->tutorials) then use **Generate Surface** and **Surface View** to obtain a similar view.



Data visualization: exercise 3

Solution

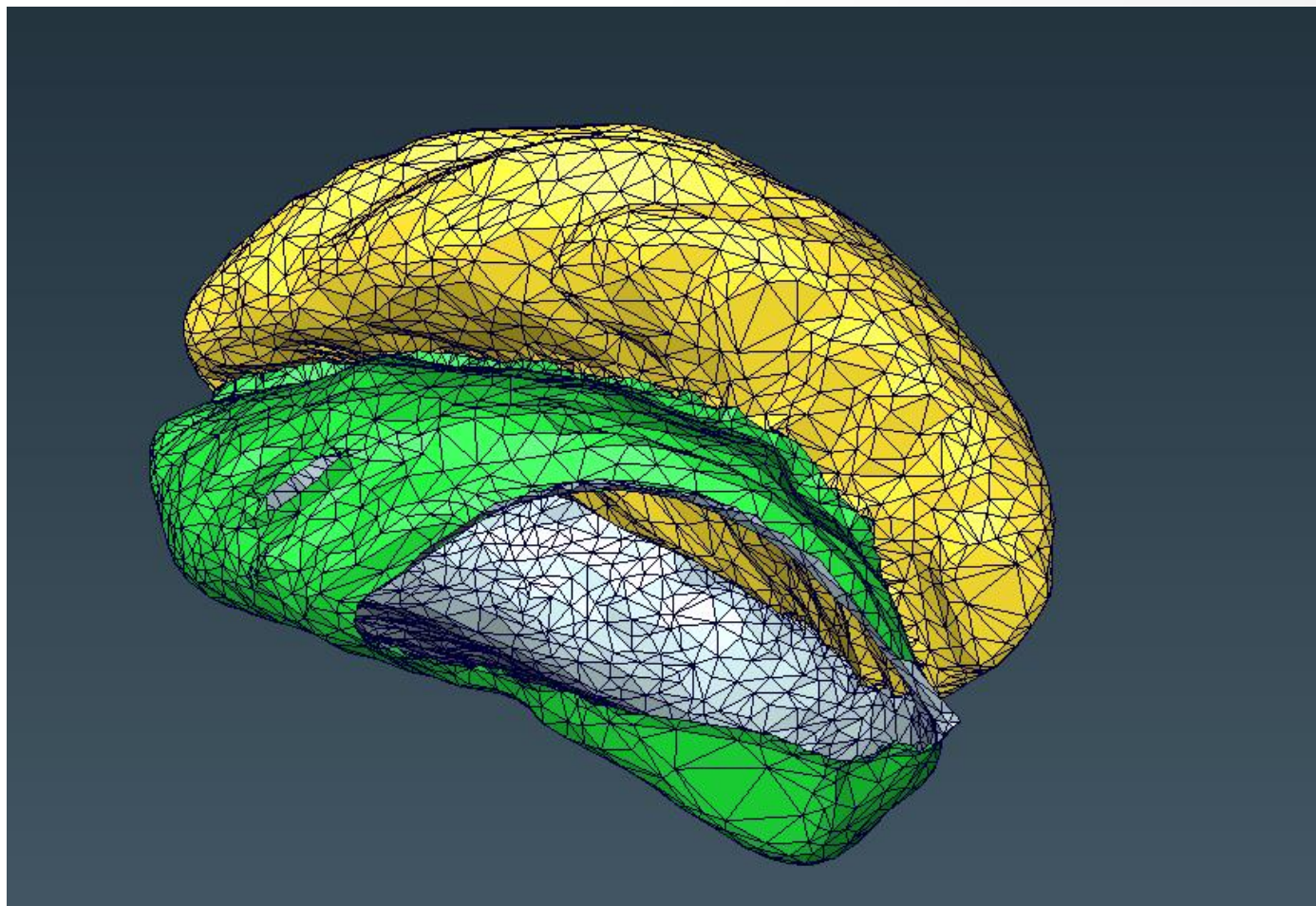
1. **Generate Surface:**
 - Smoothing: Existing Weights
2. **Simplify Surface:**
 - 18000 faces
3. **Surface View:**
 - Draw Style: Outline
 - Colors: Patch
 - Buffer: Remove Material3



Surface view: exercise

Tuning Surface View module

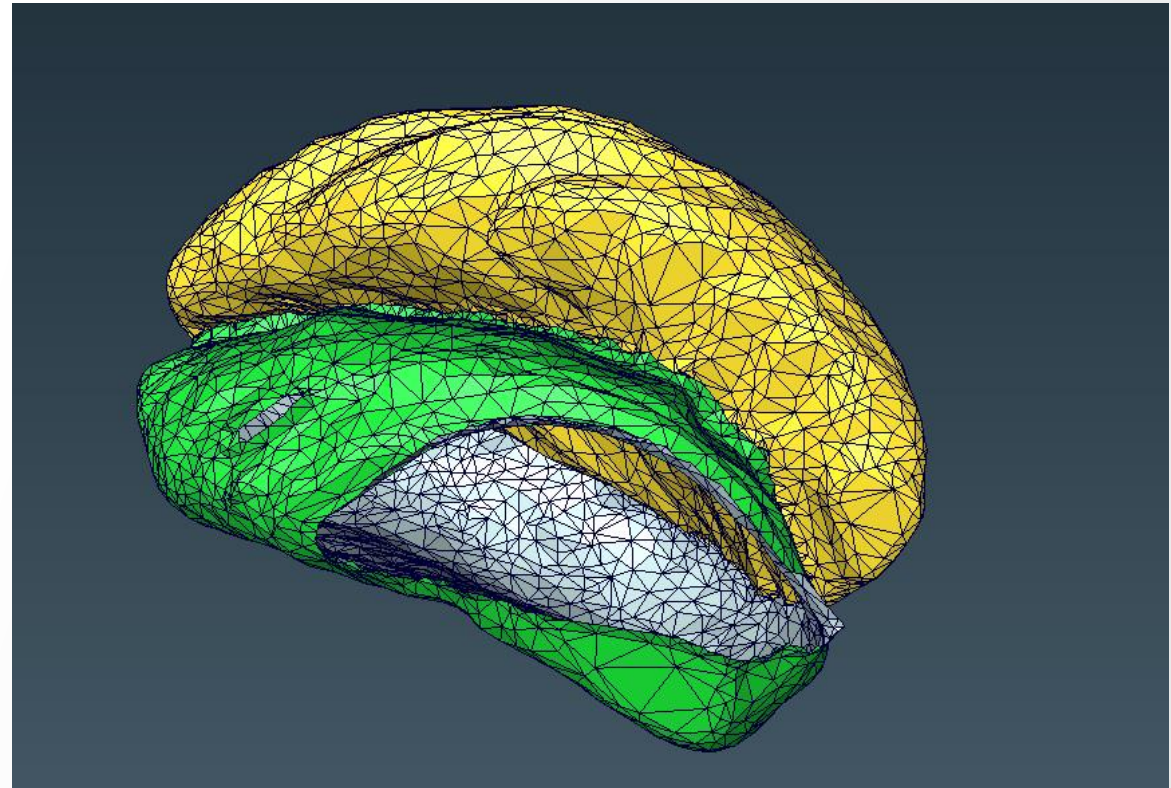
Load `lobus.labels` (data>tutorials) then use `Generate Surface` and `Surface View` to obtain a similar view.



Data visualization: exercise 3

Solution

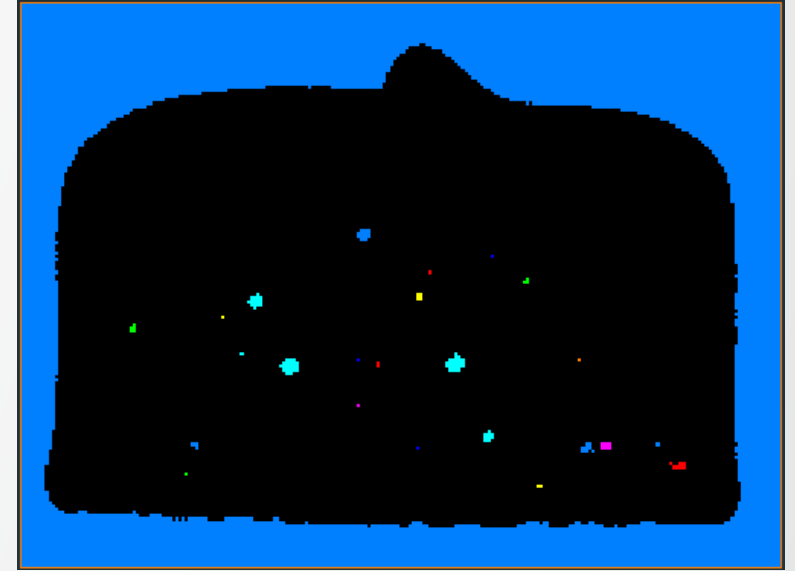
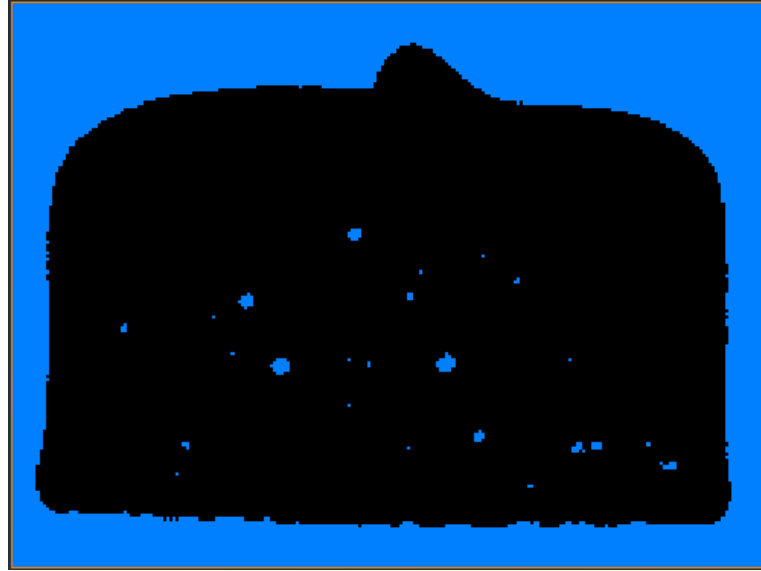
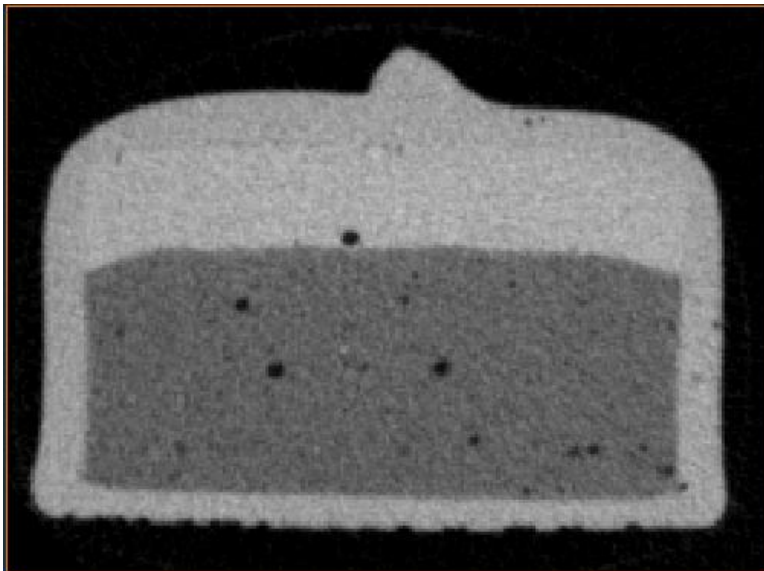
1. **Generate Surface:**
 - Smoothing: Existing Weights
2. **Simplify Surface:**
 - 18000 faces
3. **Surface View:**
 - Draw Style: Outline
 - Colors: normal
 - Buffer: Remove Medulla



Quantification

Quantification on segmentation results

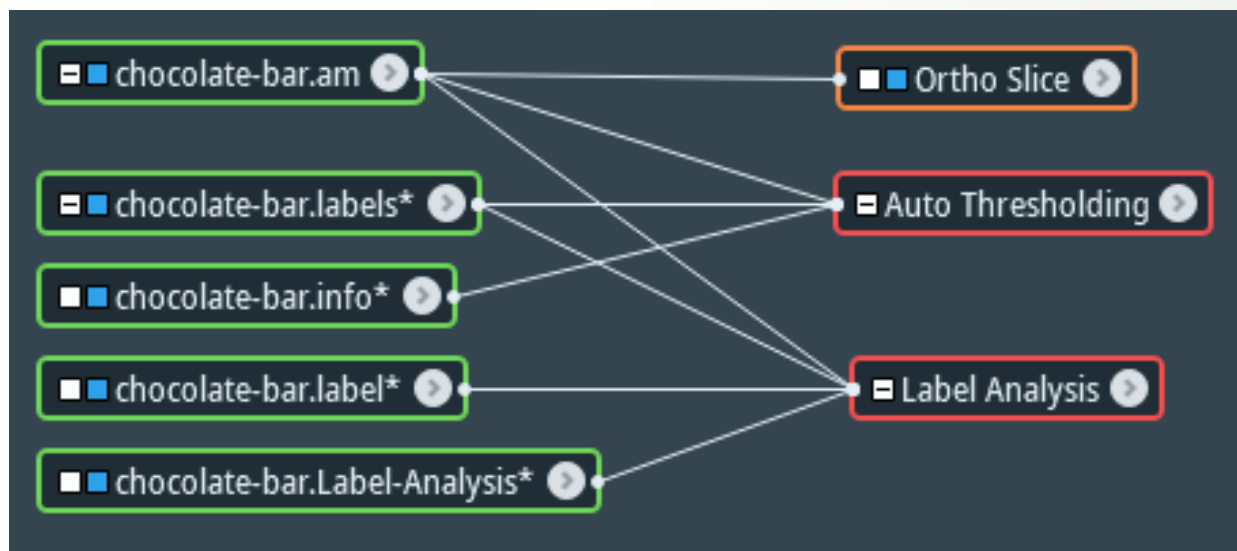
Q: How can one identify segmentation objects and extract measurements and statistics ?



Label segmentation objects and extract measures

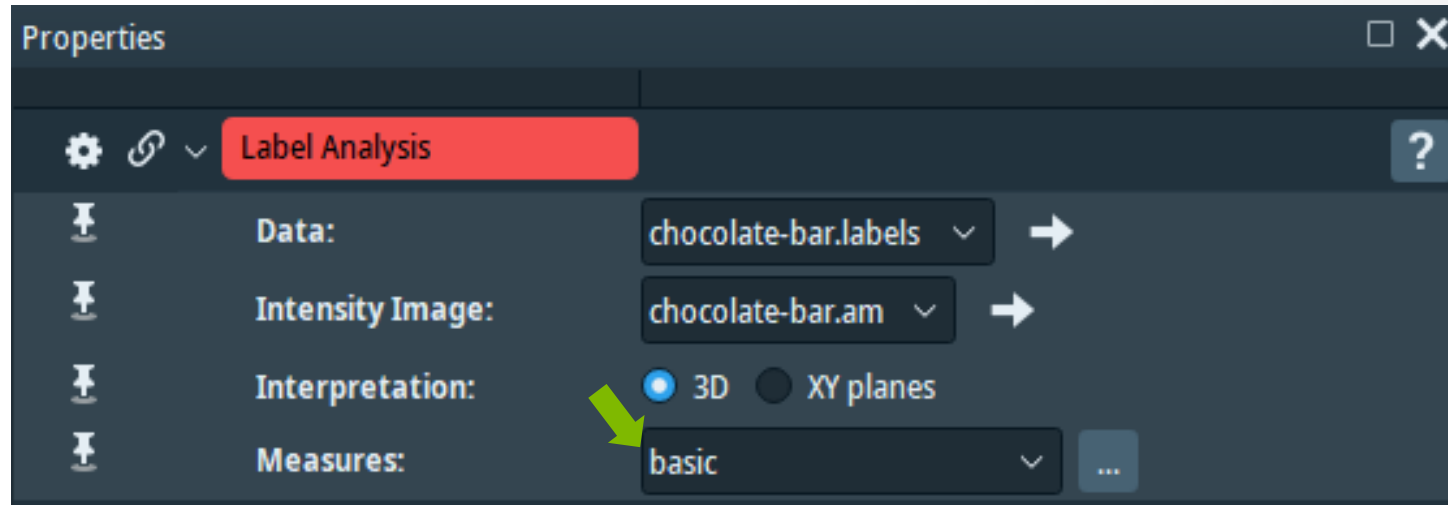
A: **Label Analysis** module. It

- Generates a label image: a unique label is assigned to each connected component (if input is binary)
- Allows extracting **individual measures** for each label object
- Allows extracting **global statistics**
- Intensity input (optional): allows extracting gray level statistics (e.g. mean, min, max)



Label Analysis

A: Label Analysis module. Default port initialization:

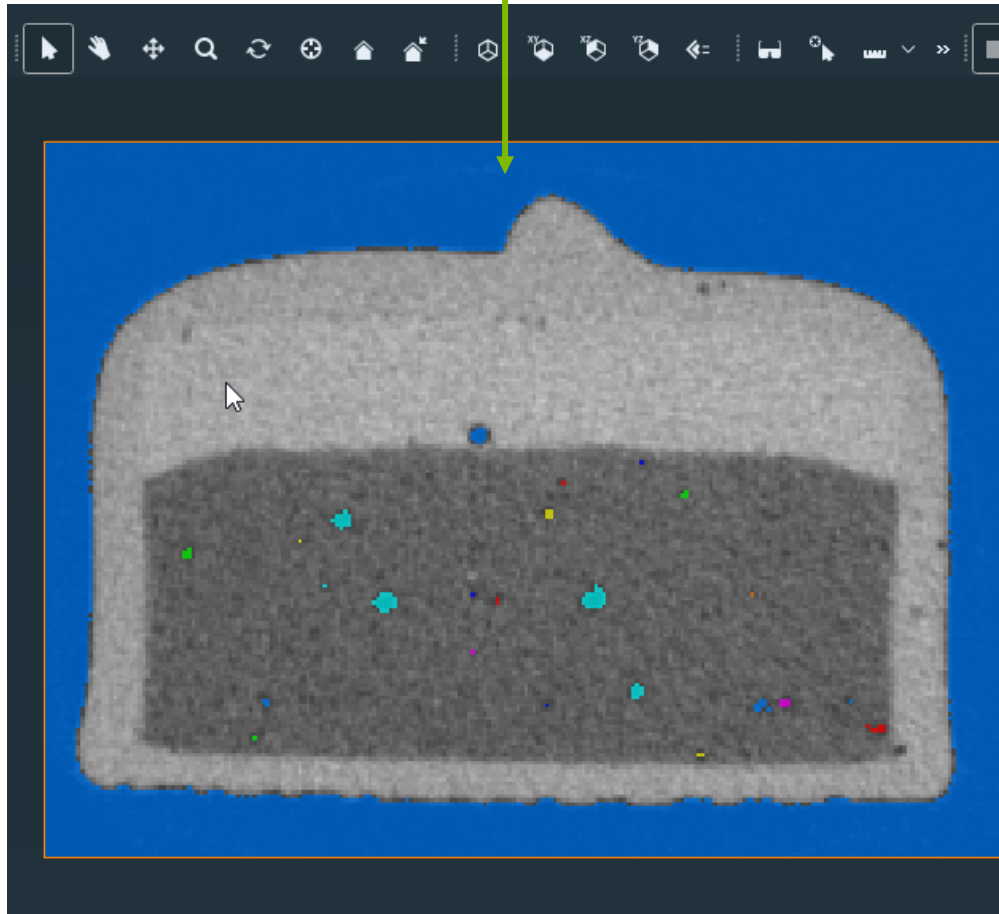


- “basic” Measures – group of pre-defined measures:
 - Volume3d
 - Area3d
 - BaryCenterX
 - BaryCenterY
 - BaryCenterZ
 - Mean

Label Analysis

Label Analysis results for default ports initialization.

Labeled image (overlaid on input)



Global statistics

Individual measures

Tables

chocolate-bar.Label-Analysis

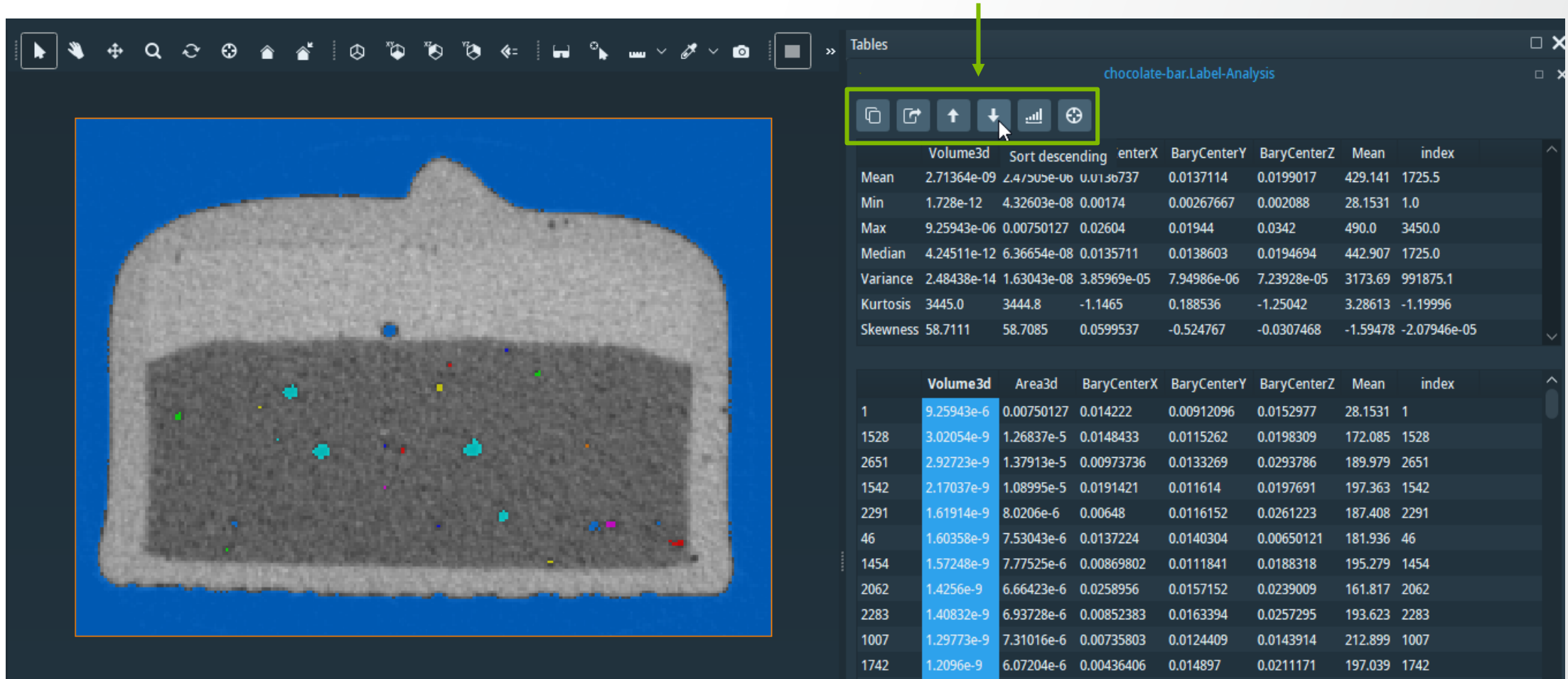
	Volume3d	Area3d	BaryCenterX	BaryCenterY	BaryCenterZ	Mean	index
Mean	2.71364e-09	2.47505e-06	0.0136737	0.0137114	0.0199017	429.141	1725.5
Min	1.728e-12	4.32603e-08	0.00174	0.00267667	0.002088	28.1531	1.0
Max	9.25943e-06	0.00750127	0.02604	0.01944	0.0342	490.0	3450.0
Median	4.24511e-12	6.36654e-08	0.0135711	0.0138603	0.0194694	442.907	1725.0
Variance	2.48438e-14	1.63043e-08	3.85969e-05	7.94986e-06	7.23928e-05	3173.69	991875.1
Kurtosis	3445.0	3444.8	-1.1465	0.188536	-1.25042	3.28613	-1.19996
Skewness	58.7111	58.7085	0.0599537	-0.524767	-0.0307468	-1.59478	-2.07946e-05

	Volume3d	Area3d	BaryCenterX	BaryCenterY	BaryCenterZ	Mean	index
1	9.25943e-6	0.00750127	0.014222	0.00912096	0.0152977	28.1531	1
2	8.64e-12	1.75547e-7	0.011616	0.018168	0.002088	430.6	2
3	3.456e-12	8.12381e-8	0.01392	0.01782	0.00312	423.5	3
4	9.8496e-11	1.01297e-6	0.0167053	0.0162358	0.00393053	211.404	4
5	2.2464e-11	3.52903e-7	0.0161354	0.01344	0.00403385	368.692	5
6	1.728e-12	4.32603e-8	0.00888	0.01596	0.00396	400.0	6
7	2.0736e-11	3.36868e-7	0.01493	0.01792	0.00409	352.833	7
8	5.184e-12	1.16227e-7	0.01272	0.01748	0.00412	453.0	8
9	1.48608e-10	1.35403e-6	0.00850884	0.0168614	0.00453767	213.105	9
10	4.1472e-11	5.46083e-7	0.00662	0.01764	0.00433	293.667	10
11	1.728e-12	4.32603e-8	0.02064	0.0114	0.00432	485.0	11

Label Analysis

Different **tools** are available for manipulating the spreadsheet measures:

- E.g. “Sort descending” sorts the values of a column in descending order.



The screenshot displays the ThermoFisher software interface. On the left, a 3D model of a chocolate bar is shown with a blue background. On the right, a data table titled "chocolate-bar.Label-Analysis" is visible. The table has two sections. The top section shows summary statistics for the "Volume3d" column, which is sorted in descending order. The bottom section shows a list of individual data points for the "Volume3d" column, also sorted in descending order. A green arrow points to the "Sort descending" icon (a downward arrow) in the toolbar above the table.

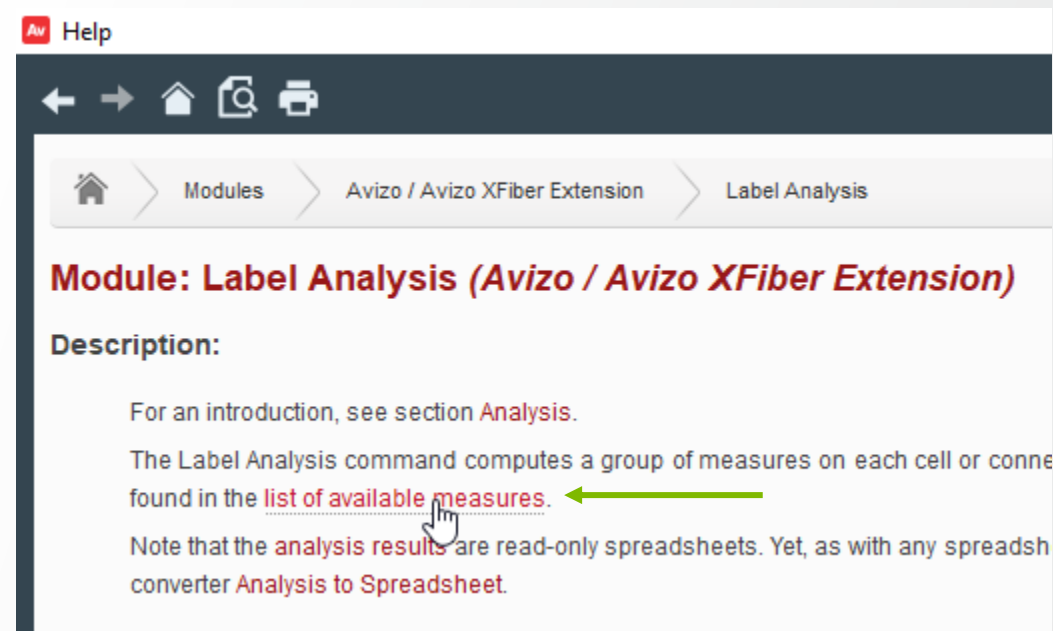
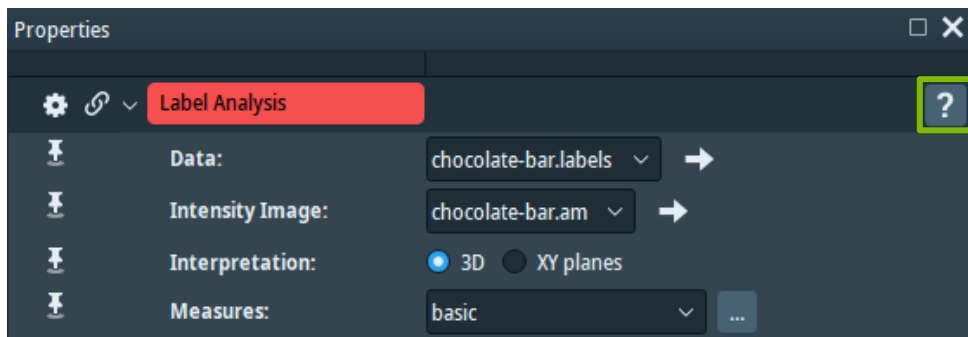
	Volume3d	Sort descending	enterX	BaryCenterY	BaryCenterZ	Mean	index
Mean	2.71364e-09	2.47505e-06	0.0136737	0.0137114	0.0199017	429.141	1725.5
Min	1.728e-12	4.32603e-08	0.00174	0.00267667	0.002088	28.1531	1.0
Max	9.25943e-06	0.00750127	0.02604	0.01944	0.0342	490.0	3450.0
Median	4.24511e-12	6.36654e-08	0.0135711	0.0138603	0.0194694	442.907	1725.0
Variance	2.48438e-14	1.63043e-08	3.85969e-05	7.94986e-06	7.23928e-05	3173.69	991875.1
Kurtosis	3445.0	3444.8	-1.1465	0.188536	-1.25042	3.28613	-1.19996
Skewness	58.7111	58.7085	0.0599537	-0.524767	-0.0307468	-1.59478	-2.07946e-05

	Volume3d	Area3d	BaryCenterX	BaryCenterY	BaryCenterZ	Mean	index
1	9.25943e-6	0.00750127	0.014222	0.00912096	0.0152977	28.1531	1
1528	3.02054e-9	1.26837e-5	0.0148433	0.0115262	0.0198309	172.085	1528
2651	2.92723e-9	1.37913e-5	0.00973736	0.0133269	0.0293786	189.979	2651
1542	2.17037e-9	1.08995e-5	0.0191421	0.011614	0.0197691	197.363	1542
2291	1.61914e-9	8.0206e-6	0.00648	0.0116152	0.0261223	187.408	2291
46	1.60358e-9	7.53043e-6	0.0137224	0.0140304	0.00650121	181.936	46
1454	1.57248e-9	7.77525e-6	0.00869802	0.0111841	0.0188318	195.279	1454
2062	1.4256e-9	6.66423e-6	0.0258956	0.0157152	0.0239009	161.817	2062
2283	1.40832e-9	6.93728e-6	0.00852383	0.0163394	0.0257295	193.623	2283
1007	1.29773e-9	7.31016e-6	0.00735803	0.0124409	0.0143914	212.899	1007
1742	1.2096e-9	6.07204e-6	0.00436406	0.014897	0.0211171	197.039	1742

Label Analysis: pre-defined measures list

Some measures are pre-defined and ready to use by “Label Analysis” module.
For checking the list of pre-defined measures:

- Go to “Label Analysis” Help page
- Click on “list of available measures”



Label Analysis: pre-defined measures list

Help page with the [list of pre-defined individual label measures](#).

List of individual label measures

Cooccurrence

Computing **Co-occurrence matrix** is a common method for extracting texture attributes.

Notes:

- Co-occurrence measurements rely in a distribution of different vectors that can be set in the Cooccurrence tab of the **Label Measures Attributes Editor**.
- All of these measurements are based on the intensity input image. Using them with a label or binary image as intensity image is not relevant.

Measurements usable only with 2D interpretation:

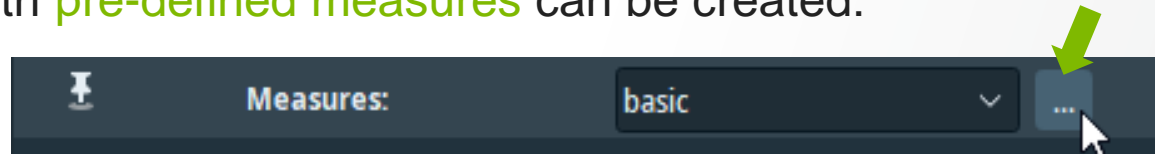
- **CooccurrenceASM**: The Co-occurrence Angular Second Moment, also called uniformity, gives high values when image pixels present strong local uniformity.
$$ASM = \sum_{i,j=1}^N M(i,j)^2$$
 with M the cooccurrence matrix and N the number of gray level.
- **CooccurrenceCon**: The Co-occurrence Contrast gives high values for great gray level variations.
$$Con = \sum_{i,j=1}^N M(i,j) \times (i-j)^2$$
- **CooccurrenceCor**: The Co-occurrence Correlation measures the dependency between gray levels and those of neighboring pixels.
$$Cor = \sum_{i,j=1}^N M(i,j) \times \frac{(i-\mu_i)(j-\mu_j)}{\sqrt{\sigma_i^2 \sigma_j^2}}$$

with $\mu_i = \mu_j = \sum_{i,j=1}^N i \times M(i,j)$
and $\sigma_i^2 = \sigma_j^2 = \sum_{i,j=1}^N (i-\mu_i)^2 \times M(i,j)$
- **CooccurrenceDEn**: Co-occurrence Difference Entropy.
$$DEn = - \sum_{k=0}^{N-1} p_{x-y}(k) \times \log(p_{x-y}(k))$$

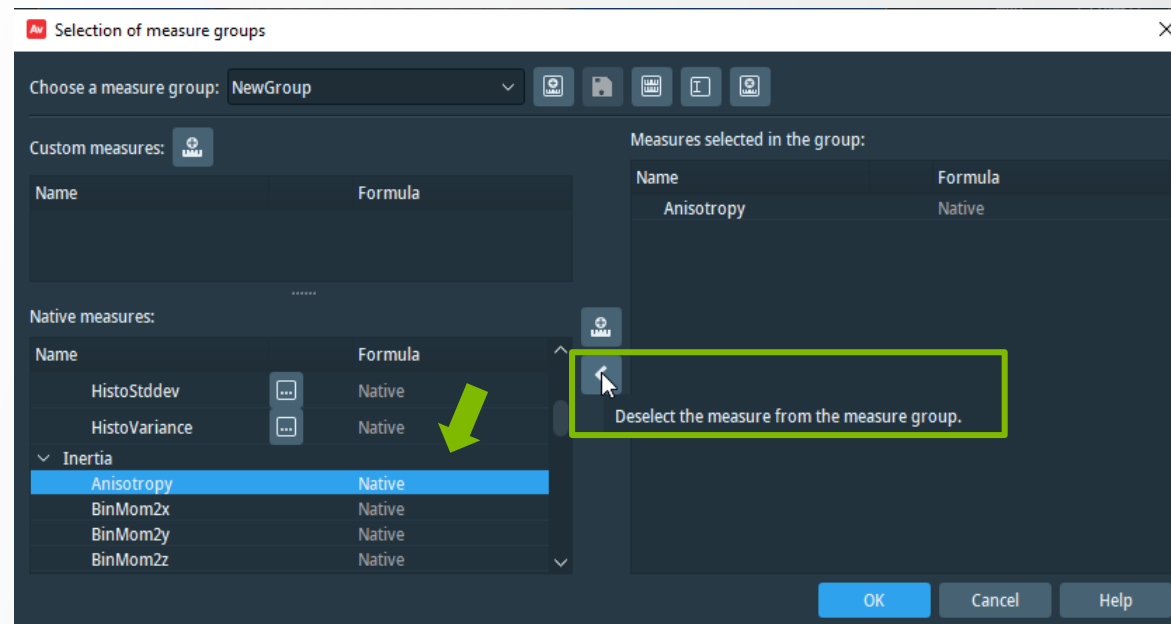
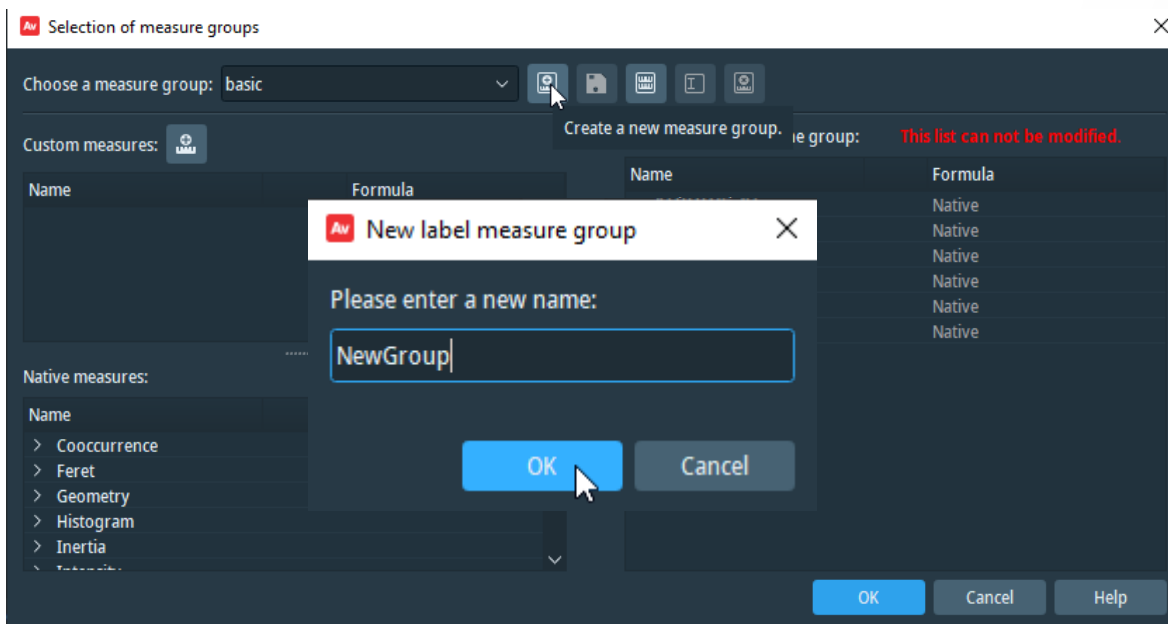
with $p_{x-y}(k) = \sum_{|i-j|=k} M(i,j)$
- **CooccurrenceDirX**: X offset defining the direction used for co-occurrence computation (dx).
- **CooccurrenceDirY**: Y offset defining the direction used for co-occurrence computation (dy).
- **CooccurrenceDVa**: Co-occurrence Difference Variance.
$$DVa = \text{variance}(p_{x-y})$$
- **CooccurrenceEnt**: Co-occurrence Entropy.
$$Ent = - \sum_{i,j=1}^N M(i,j) \times \log(M(i,j))$$
- **CooccurrenceIC1**: Co-occurrence Information measure of Correlation 1.
$$IC1 = \frac{HXY - HXY1}{\max(HX, HY)}$$

Label Analysis: custom measures list, custom measures

A custom measures list with pre-defined measures can be created:



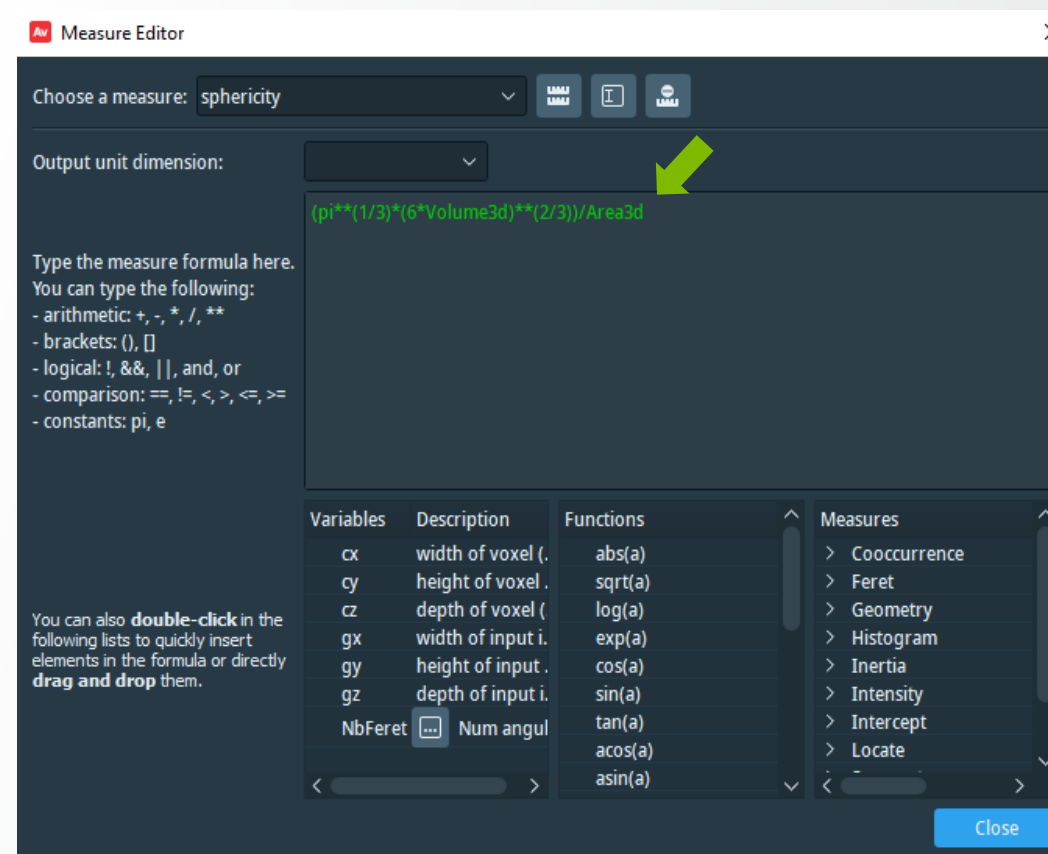
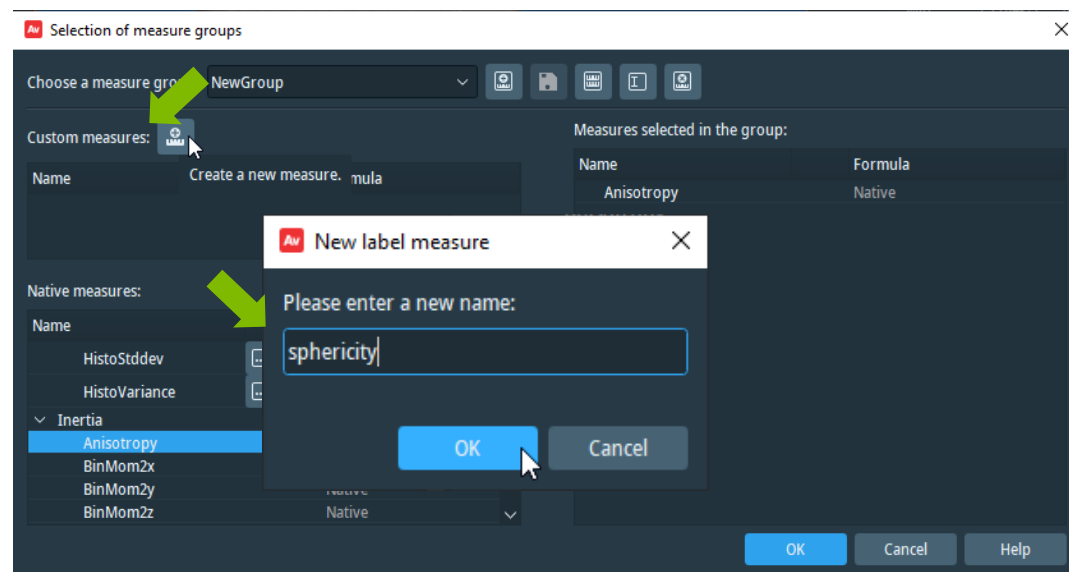
- Click on a measure on the left side to add it to the group
- Select a measure added to the group (right side) and click on “Deselect the measure from the measure group” to remove it from the group.



Label Analysis: custom measures list

Custom measures can also be created and added to the custom measures list. E.g. sphericity:

- Click on “Create a new measure” icon
- Type the name of the custom measure
- Type the measure in the “Measure Editor” (it’s green if valid, red if not).

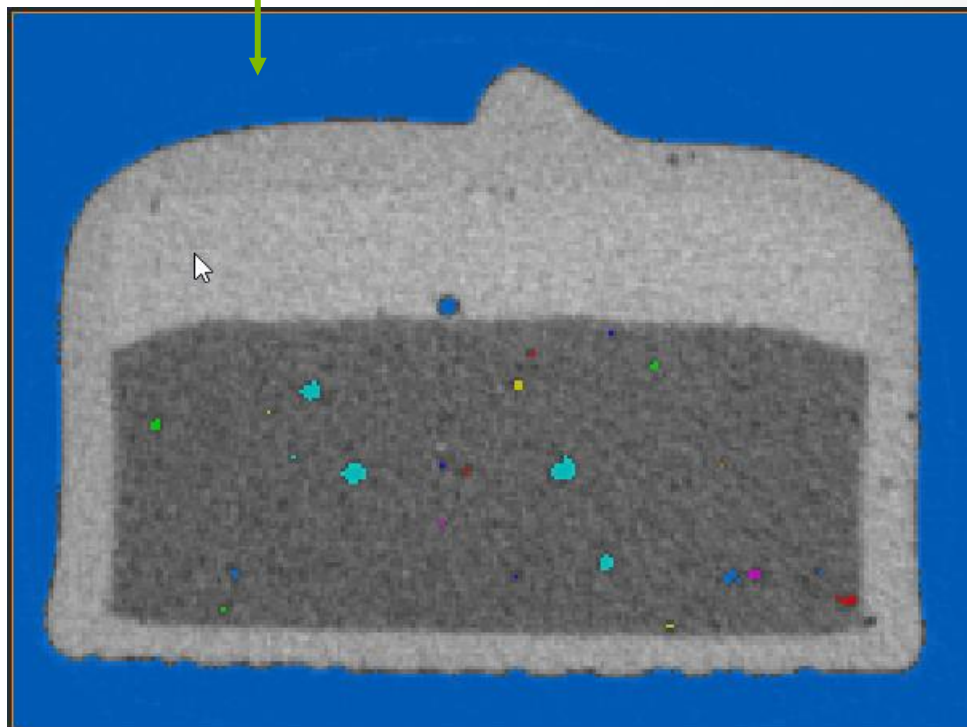


Quantification: removing unwanted detection

Q: how can one remove parasite detection from a label image and its corresponding measures in the measures spreadsheet ?

E.g.: for the segmentation example on chocolate bar, remove the label corresponding to background and keep only the porosity labels and measures

Unwanted detection to be removed



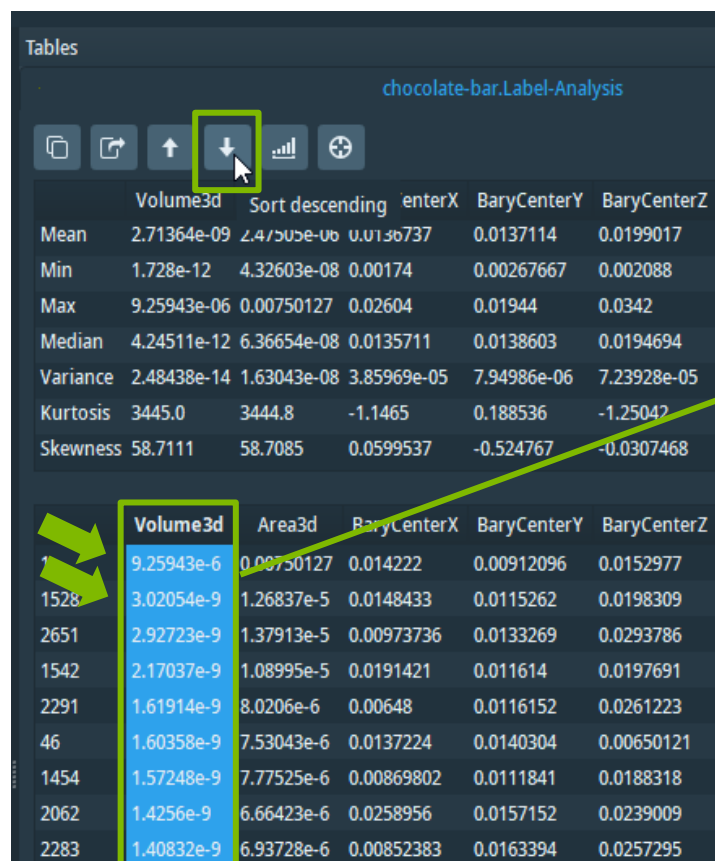
Quantification: removing unwanted detection

A: Analysis Filter module

- Filters out from the measures spreadsheet, labels that do not fulfill a filtering criterion
- Same behavior on the label image label image (when provided as input – optional)
- Filtering criterion: choose one (or more) measures that allow to discriminate the parasite detection and write filtering formula.

Tables

chocolate-bar.Label-Analysis



	Volume3d	Sort descending	centerX	BaryCenterY	BaryCenterZ
Mean	2.71364e-09	2.47505e-06	0.0136737	0.0137114	0.0199017
Min	1.728e-12	4.32603e-08	0.00174	0.00267667	0.002088
Max	9.25943e-06	0.00750127	0.02604	0.01944	0.0342
Median	4.24511e-12	6.36654e-08	0.0135711	0.0138603	0.0194694
Variance	2.48438e-14	1.63043e-08	3.85969e-05	7.94986e-06	7.23928e-05
Kurtosis	3445.0	3444.8	-1.1465	0.188536	-1.25042
Skewness	58.7111	58.7085	0.0599537	-0.524767	-0.0307468

	Volume3d	Area3d	BaryCenterX	BaryCenterY	BaryCenterZ
1	9.25943e-6	0.00750127	0.014222	0.00912096	0.0152977
1528	3.02054e-9	1.26837e-5	0.0148433	0.0115262	0.0198309
2651	2.92723e-9	1.37913e-5	0.00973736	0.0133269	0.0293786
1542	2.17037e-9	1.08995e-5	0.0191421	0.011614	0.0197691
2291	1.61914e-9	8.0206e-6	0.00648	0.0116152	0.0261223
46	1.60358e-9	7.53043e-6	0.0137224	0.0140304	0.00650121
1454	1.57248e-9	7.77525e-6	0.00869802	0.0111841	0.0188318
2062	1.4256e-9	6.66423e-6	0.0258956	0.0157152	0.0239009
2283	1.40832e-9	6.93728e-6	0.00852383	0.0163394	0.0257295

Properties

Analysis Filter

Label Analysis: chocolate-bar.Label-Analysis

Image: chocolate-bar.label

Filter: **Volume3d < 1e-7**

Formula is valid

Volume3d

Area3d

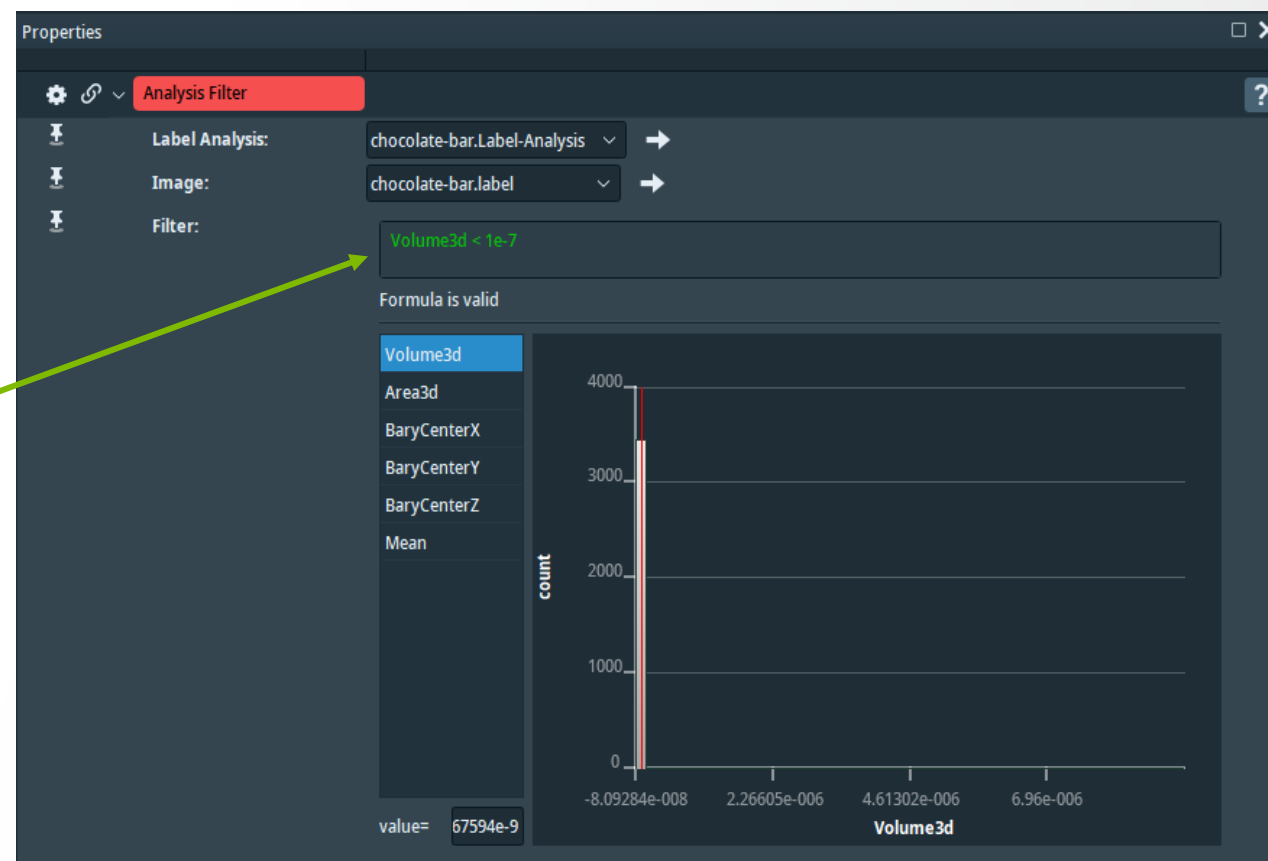
BaryCenterX

BaryCenterY

BaryCenterZ

Mean

value= 67594e-9

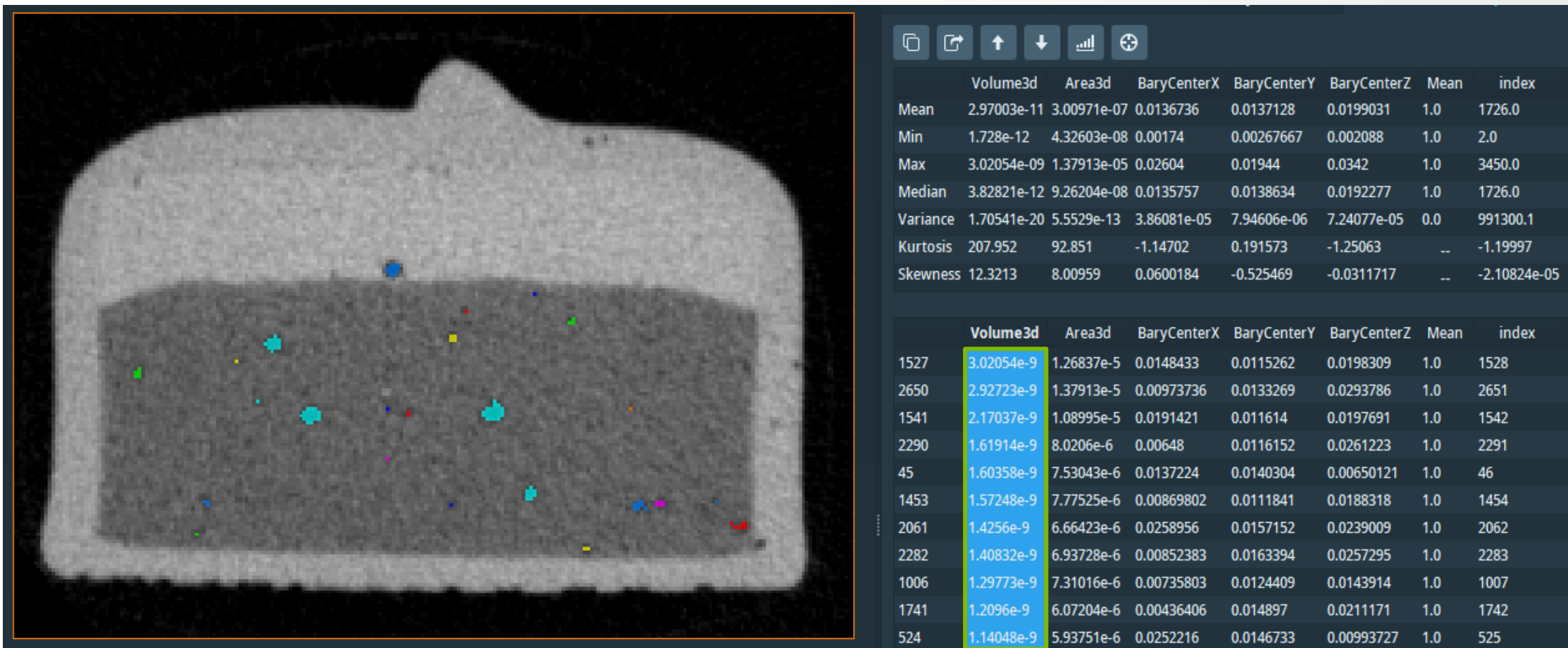


count

Volume3d

Quantification: removing unwanted detection

Analysis Filter result for the filtering formula "Volume3d < 1e-7":



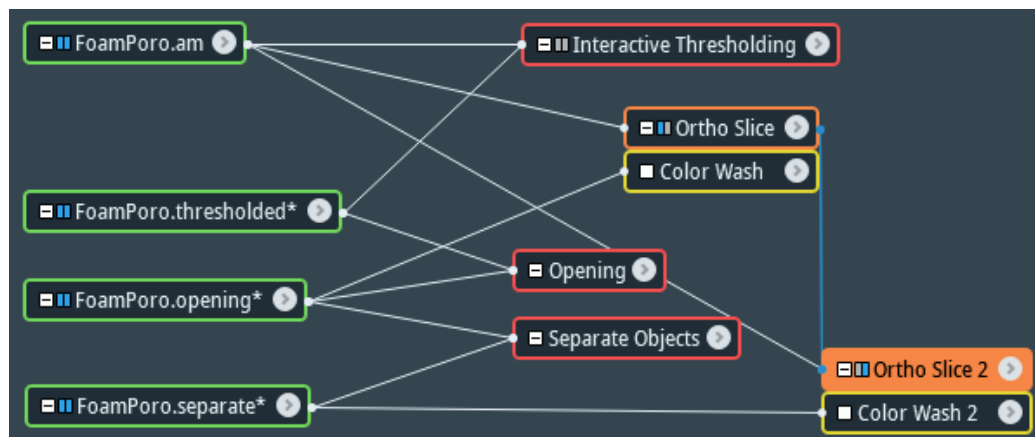
Shape analysis: represent objects as ellipsoids

Example: porosities analysis in *FoamPoro.am*

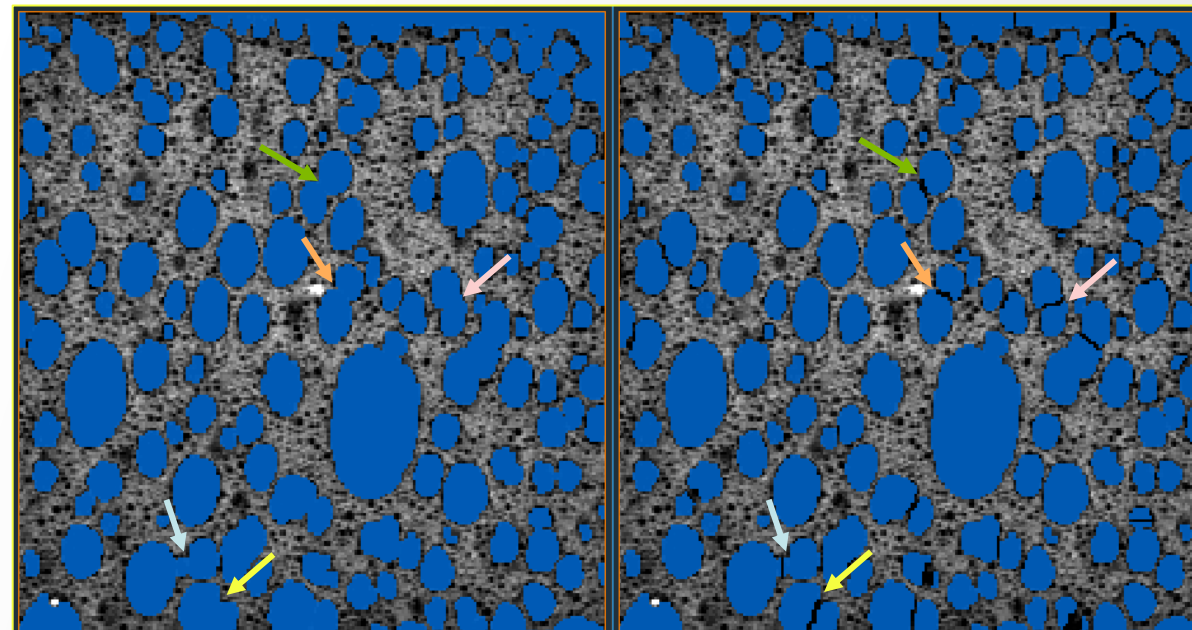
Step 1:

- Do a binary segmentation of the porosities

Segmentation workflow



Porosities before and after object **separation**

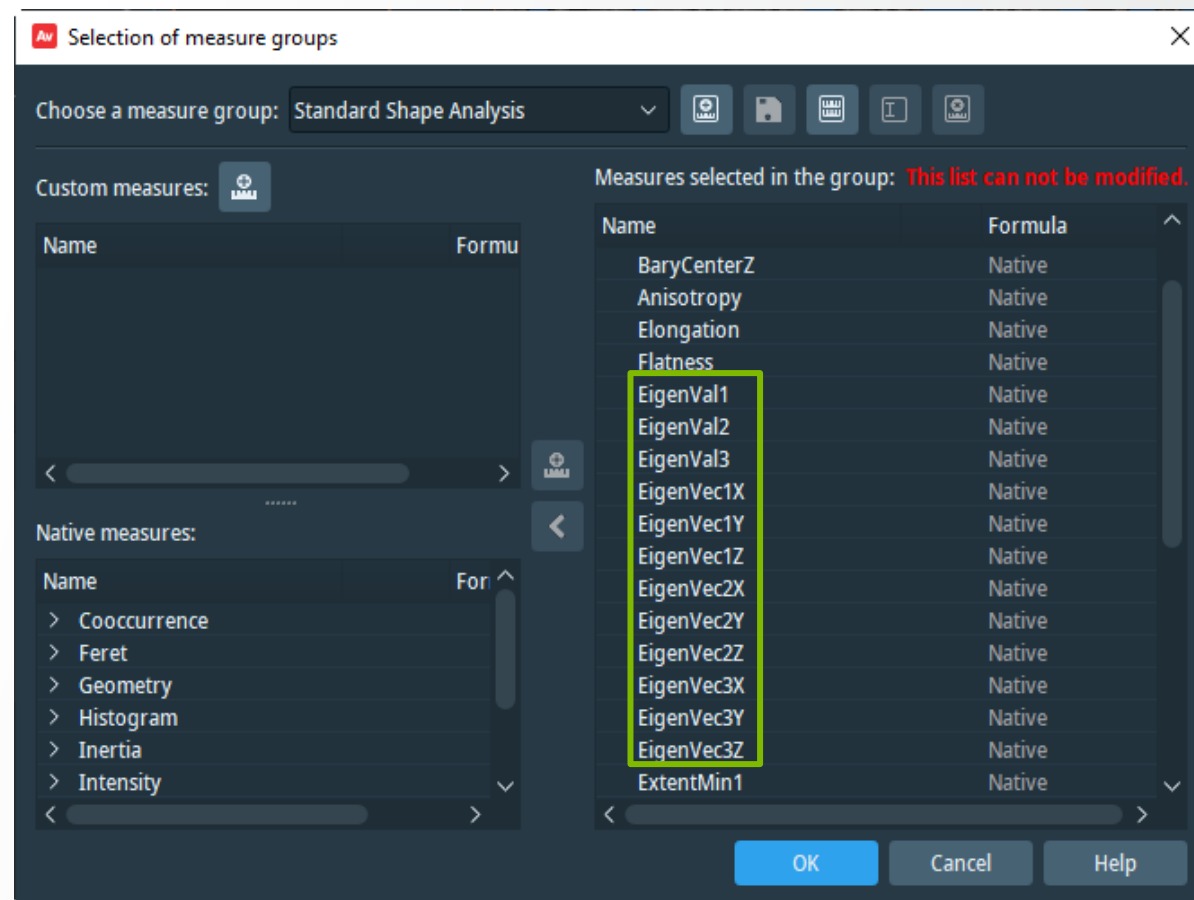
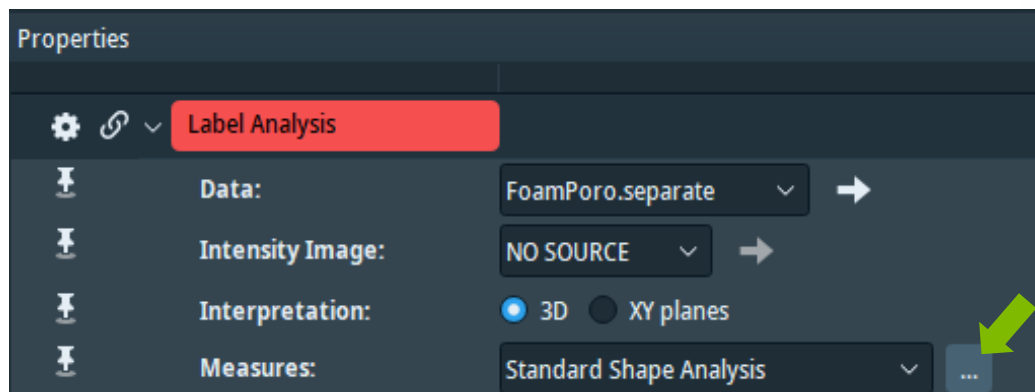


Shape analysis: represent objects as ellipsoids

Example: porosities analysis in *FoamPoro.am*

Step 2:

- Apply Label Analysis with “Standard Shape Analysis”
- Measures for shape analysis:
 - Eigenvectors
 - Eigenvalues

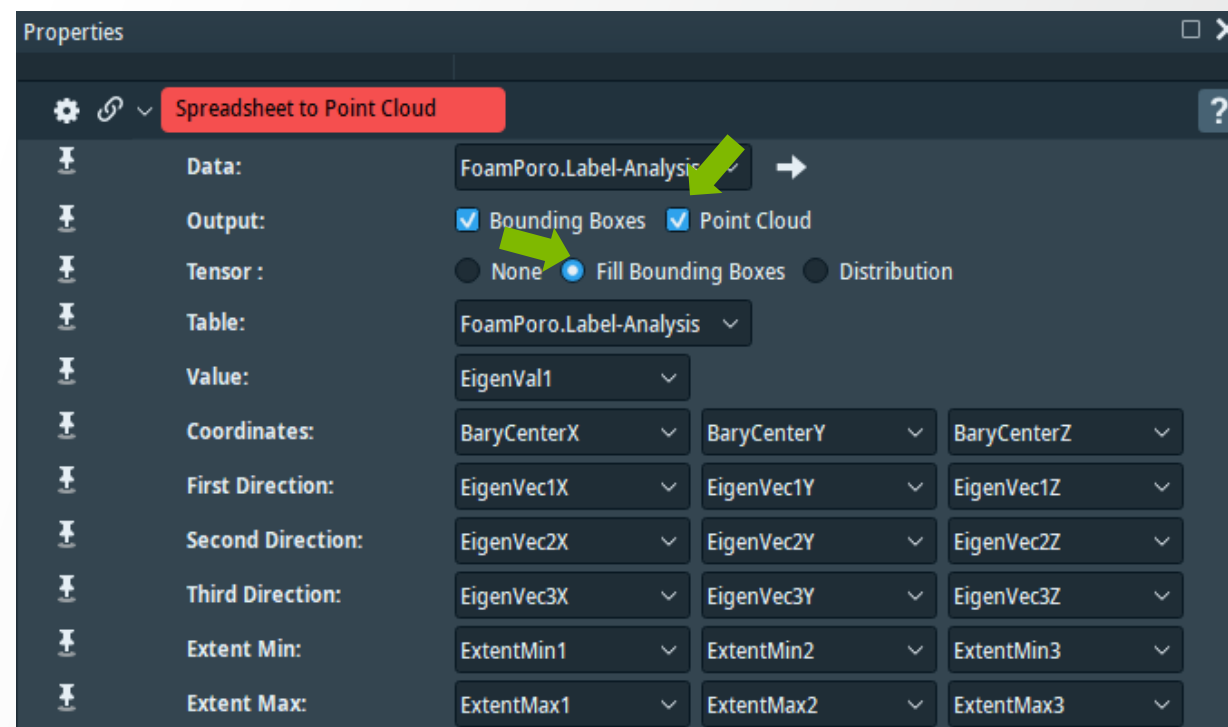
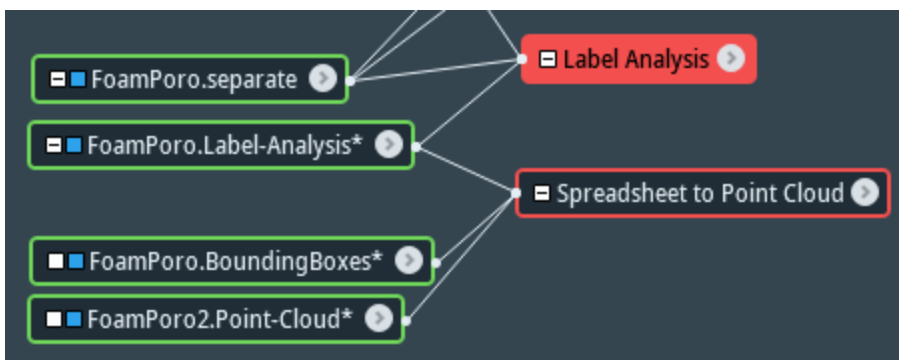


Shape analysis: represent objects as ellipsoids

Example: porosities analysis in *FoamPoro.am*

Step 3:

- Generate Bounding Box and Ellipsoid representation for individual labels via “**Spreadsheet to Point Cloud**” module
 - Check “Bounding Boxes” Output
 - Check “Point Cloud” Output and “Fill Bounding Boxes” for **ellipsoid representation**

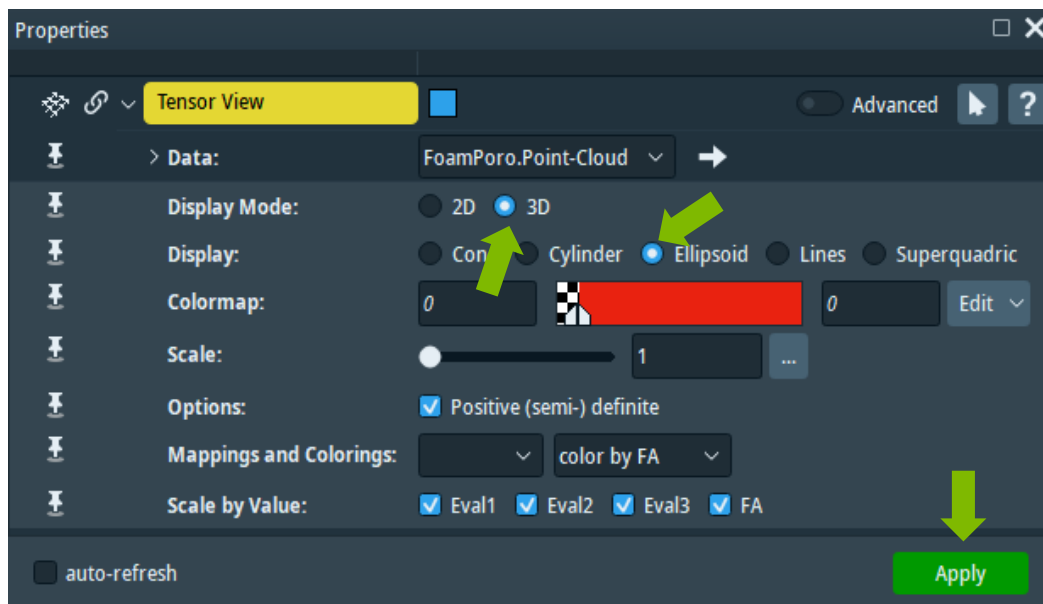
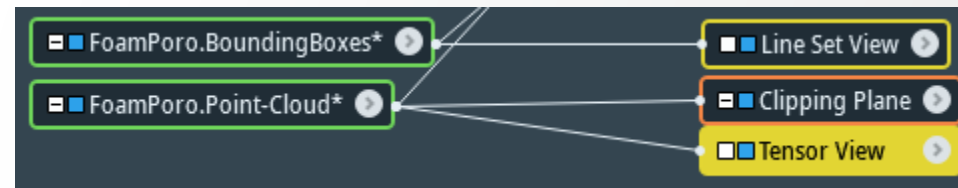


Shape analysis: represent objects as ellipsoids

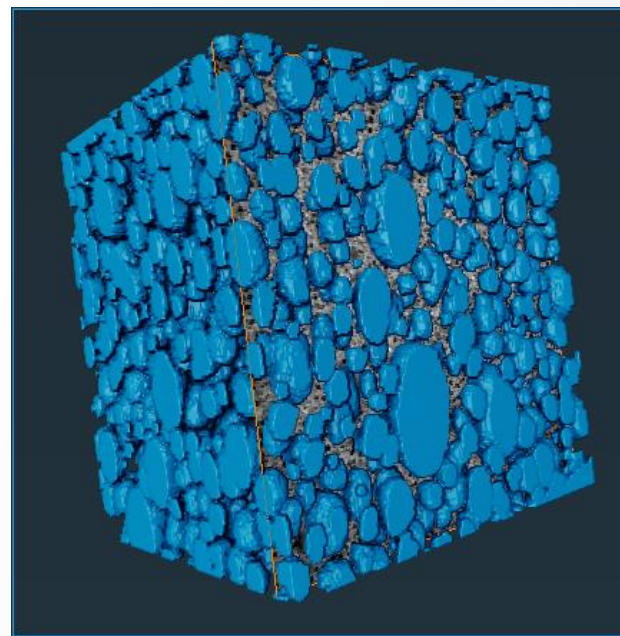
Example: porosities analysis in *FoamPoro.am*

Step 4:

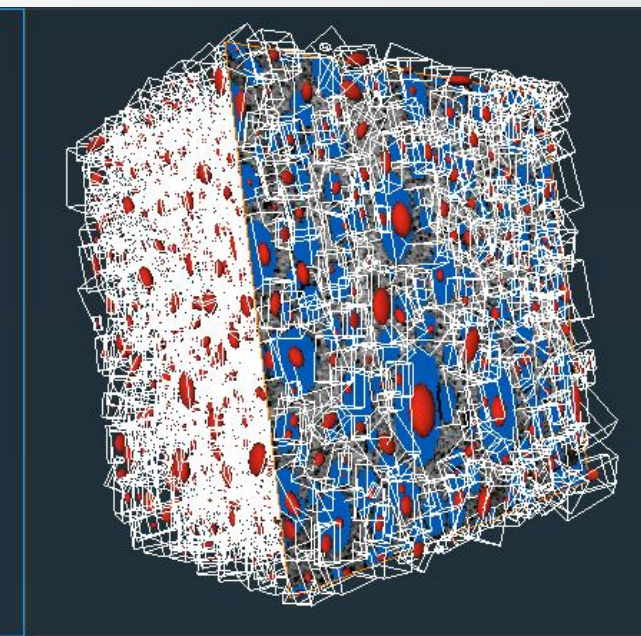
- Visualization:
 - Line Set View for Bounding Boxes
 - Tensor View for the ellipsoids (click on "Apply" for generating the visualization)



Binarisation representation

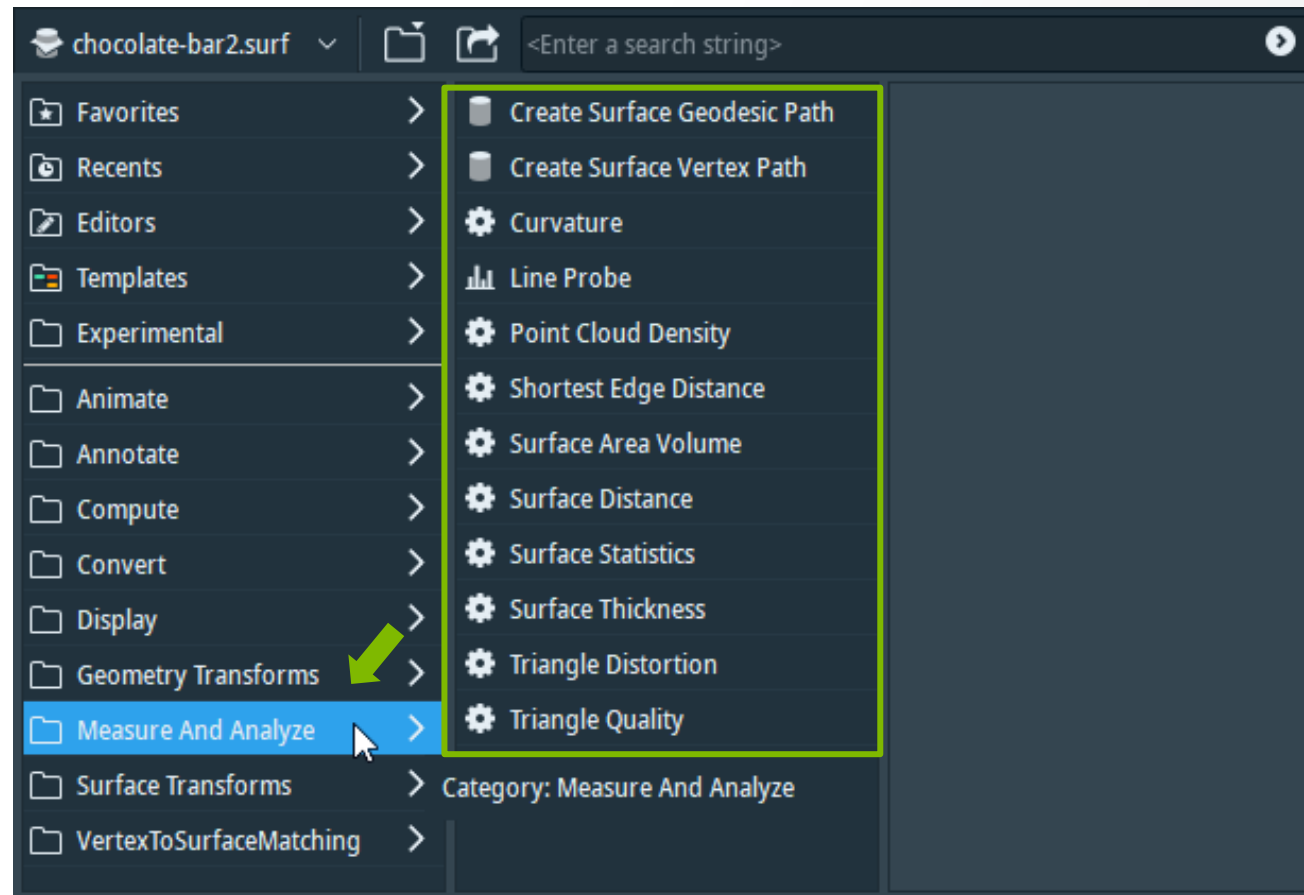


Bounding Boxes and Ellipsoid representation



Surface measurements and statistics

Other Surface measurements and statistics modules are available in the “Measure and Analyze” object category (for access: right click on the surface object in the pool).



Extract skeletons and graphs

For filamentous data, automatic extraction of centerlines with local thickness can be done via **Auto Skeleton** module. It generates a spatial graph data:

- Spreadsheet with information on nodes, points (thickness info available too), and segments

- Can be visualized with:

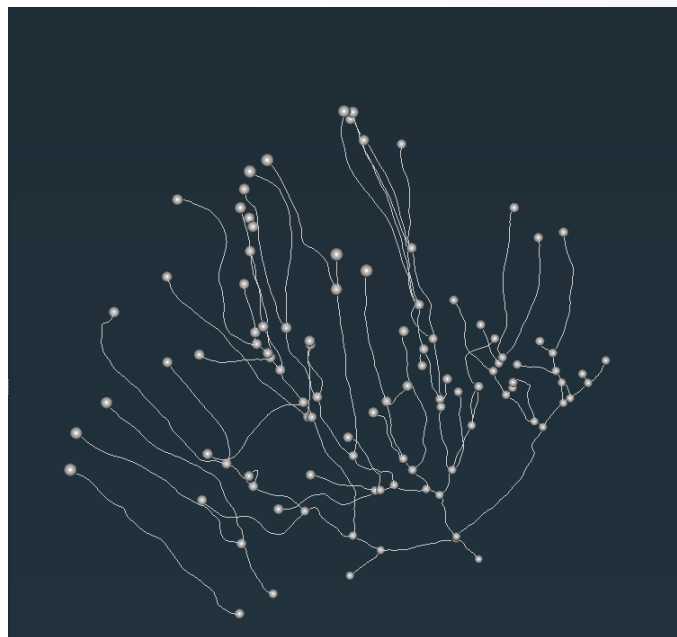


Example: *neuron.am* and *Neuron-SpatialGraph.am* data in ...\\data\tutotials\neuron

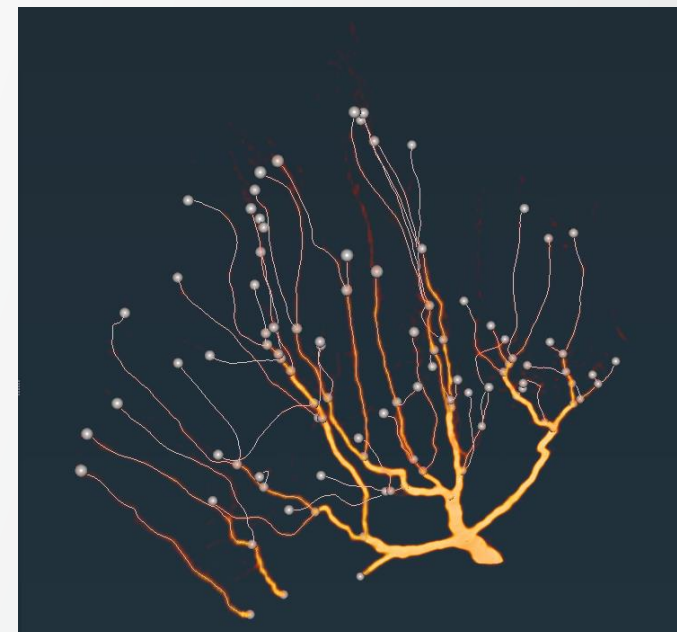
Neuron data



Neuron spatial graph



Neuron data and spatial graph
superposed



Measurements and annotations

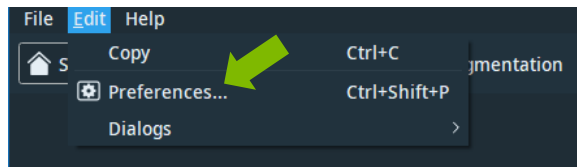
Units management

- Units are necessary to interpret numbers as physical values.
 - Two “types” of units must be distinguished:
 - **Working units:**
 - All calculations are done in those units.
 - Can only be **changed before loading the first data-set** in the project.
 - **Display units:**
 - Used to display numerical values.
 - Can be **changed anytime**, independently of working units
- Note:** Display Units do not change data.

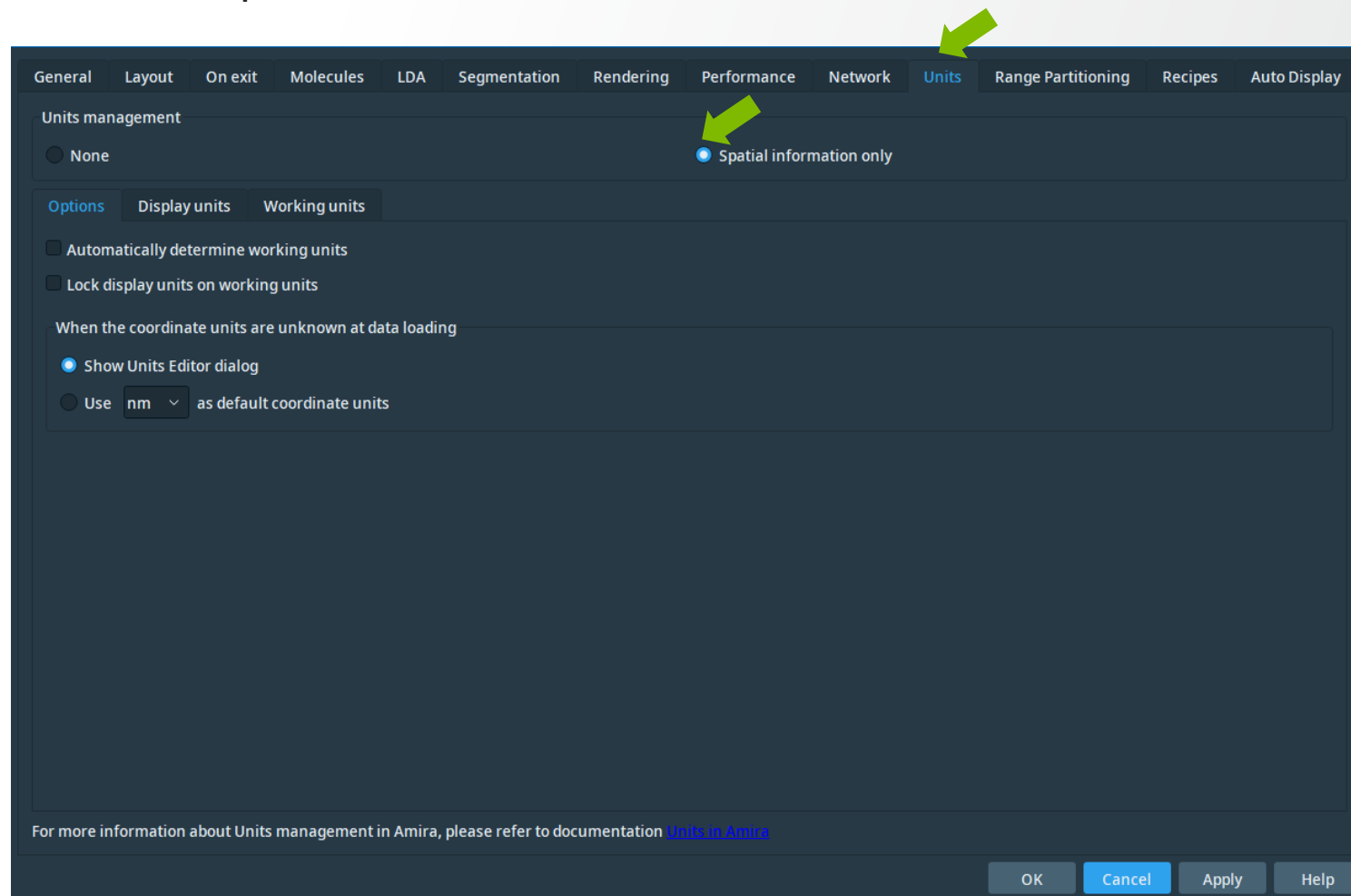
Use **adequate working** units because of the **impact on numerical precision!**

Units management

- Units management is implemented for **spatial size only** (coordinate and angle units).
- Units management settings can be accessed in preferences:



- Default is:
 - enabled
 - (“Spatial information only”)
 - default unit: nm



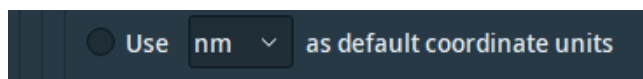
Units management

Loading data

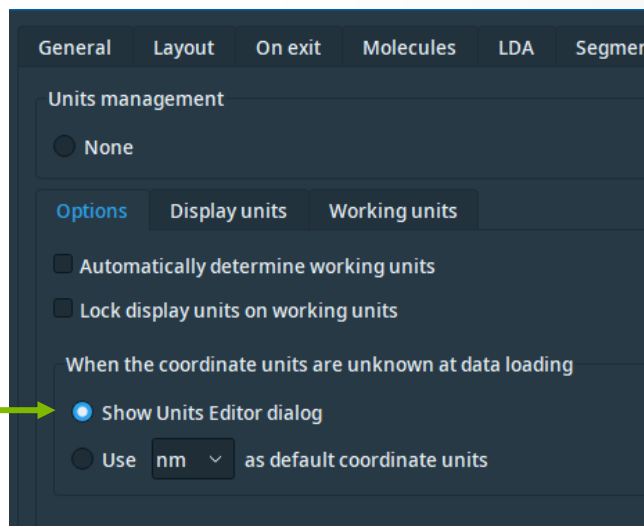
- When loading data, either spatial information is given in the same unit (default coordinate units), or the units of each data-set must be set correctly independently.

- Default setting

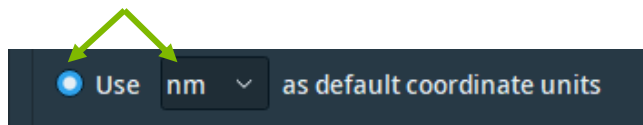
- Recommended:



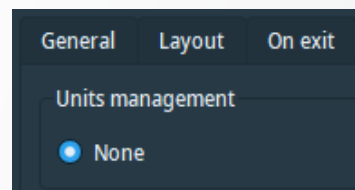
Set to your most likely unit, as this will be pre-selected in the **Units Editor dialog**.



- If you are always using data with the same unit, set the appropriate unit here:



- Alternatively, switch off units management.



Units management

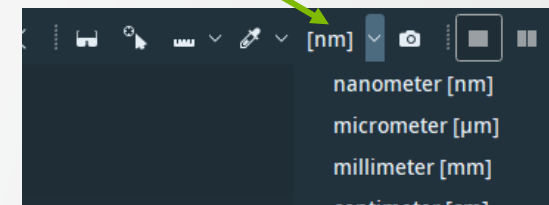
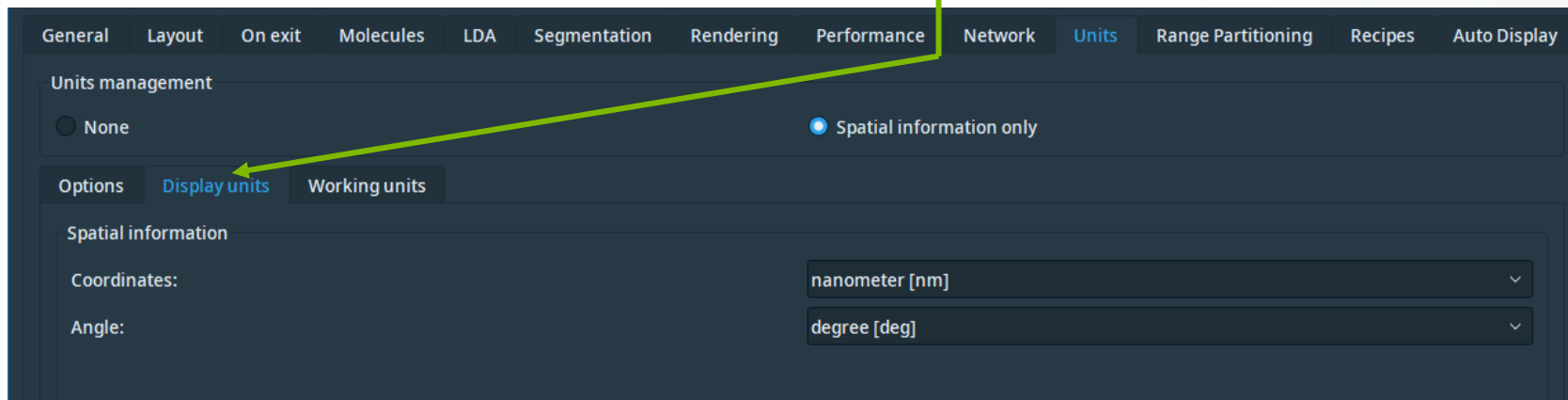
Beware:

- If you save a project, the **information about working units is saved** with it
- If you load a project having working units set differently from your current ones, the settings from the project are loaded and applied **permanently**, until you explicitly change it back!

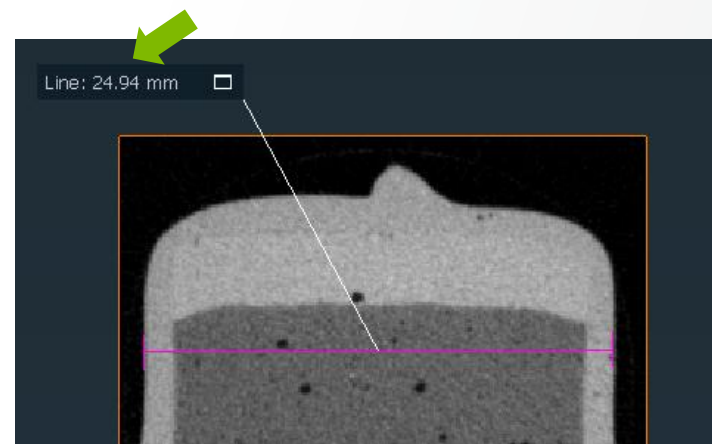
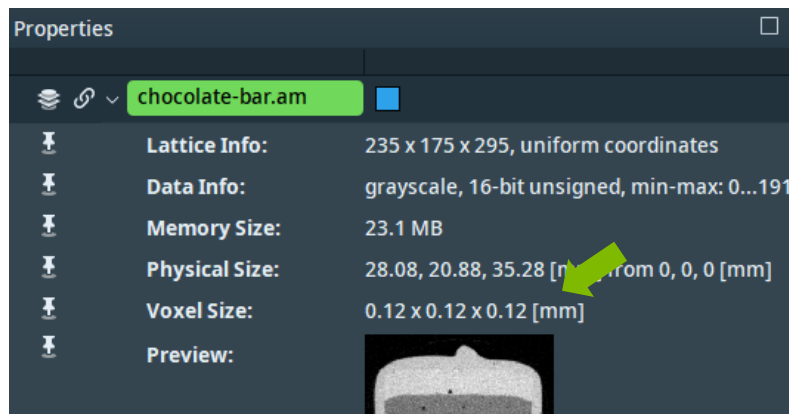
Units management

Display units:

- May be changed **anytime**, either via the preferences, or via the Viewer Window settings.



- Affect all measures with units management, e.g.:

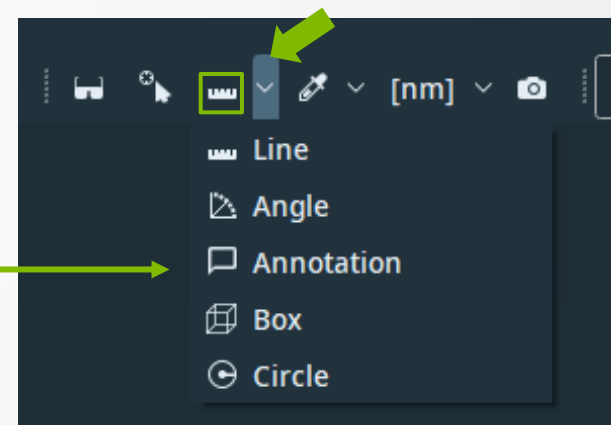


	Volume [mm ³]	CenterX [mm]	CenterY [mm]	CenterZ [mm]
1	8727.440072	14.189664	9.000797	14.037731
2	5558.680395	13.962457	13.678155	19.927394
3	2275.506384	13.893764	7.4016755	19.992448
4	3696.16773	13.876741	10.763748	18.520762
5	137.5729891	14.483729	12.459234	20.005778

Performing measurements

Measurement tool:

- invoke with
 - Measure button in viewer toolbar (shortcut “M”)
 - Via “Create object ... → Annotations → Measurement”
- Different measurements types available
- works on visualization modules in
 - 2D, e.g. Ortho Slice, Slice
 - 3D, e.g. Surface Rendering, Volume Rendering, Voxelized Rendering



Performing measurements

Measurement tool:

- is **active** when Measurement module is **selected**

The screenshot displays the software interface for performing measurements. On the left, the 'Properties' panel is active, showing the 'Measurement' module selected. The 'Pick Mode' is set to 'Fast'. The 'Snapping' section is checked, with 'Width' set to 30, 'Snap' set to 'chocolate-bar.am', and 'Trigger' set to 'Snap-it'. The 'Text' section is also checked, with 'Title' set to 'Line'. A 'Note' field is present but empty. The 'Callout Properties' and 'Shape Properties' sections are unchecked. The 'auto-refresh' checkbox is also unchecked. An 'Apply' button is visible at the bottom right of the Properties panel.

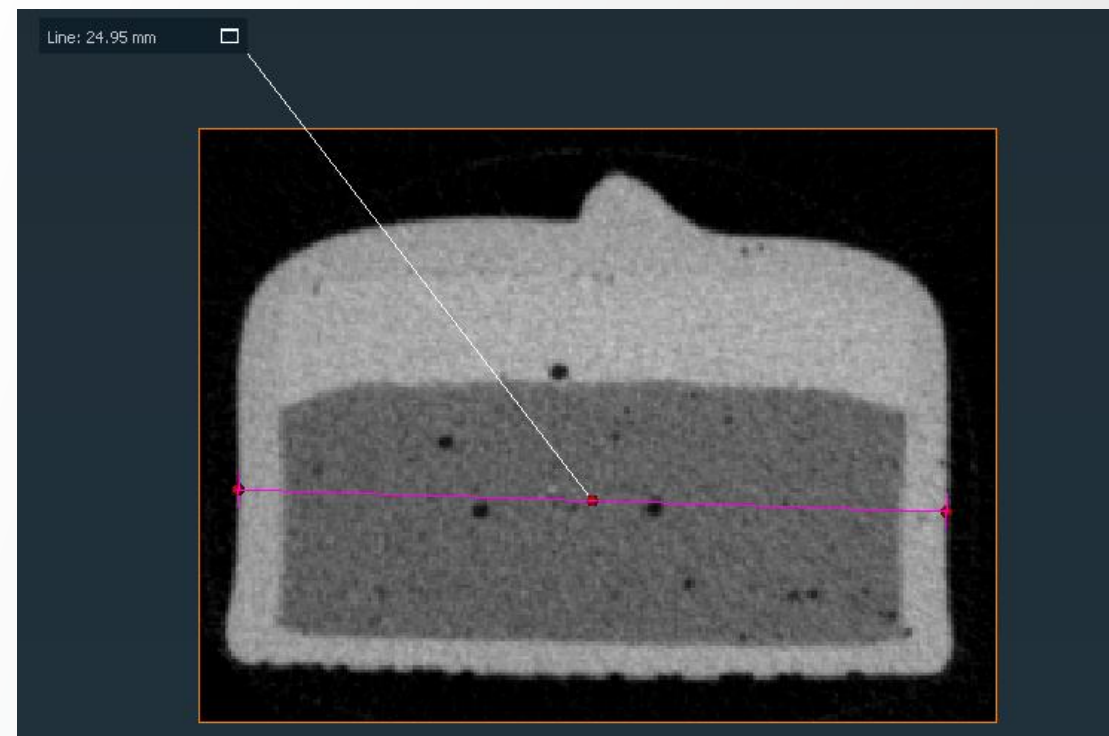
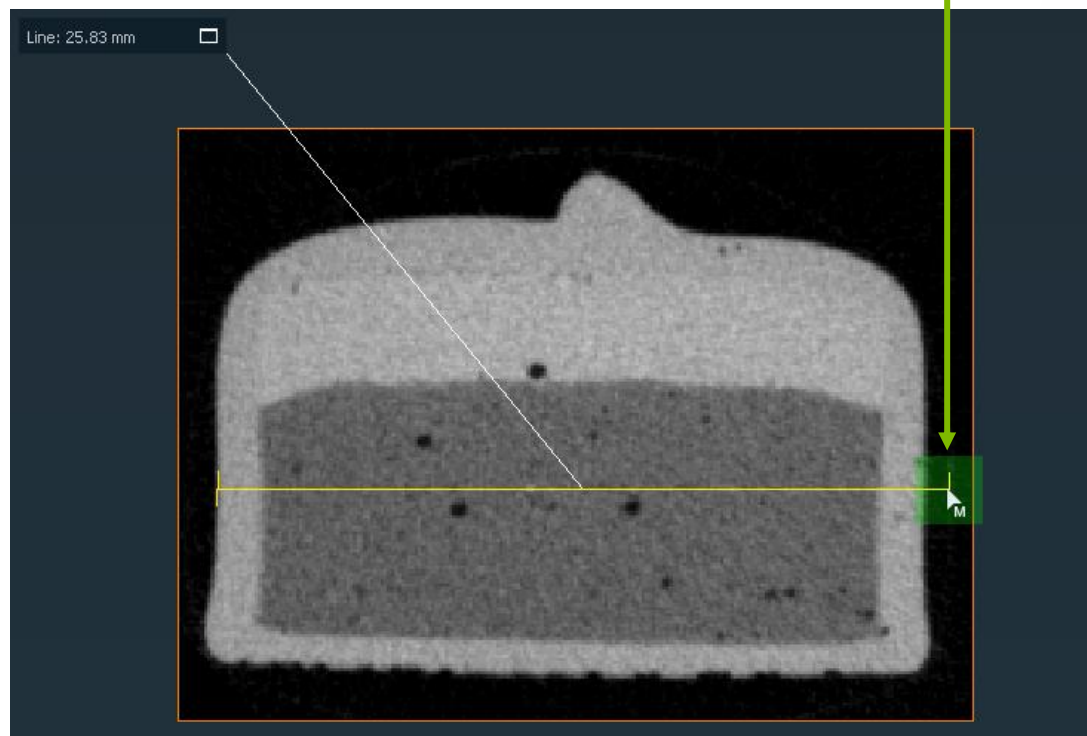
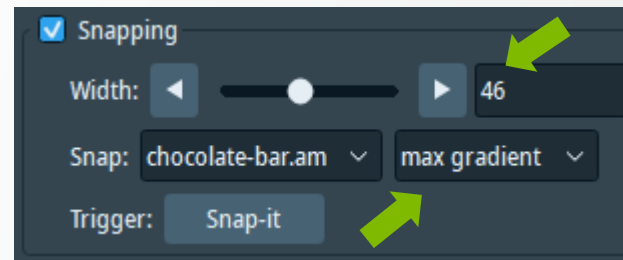
On the right, a grayscale image of a chocolate bar is shown. A horizontal line is drawn across the width of the bar, with a callout box indicating 'Line: 24.95 mm'. A 'Note' callout box is also present, containing the text 'Caramel phase'. A green arrow points from the 'Measurement' module in the Properties panel to the 'Line: 24.95 mm' callout box. Another green arrow points from the 'Note' callout box to the 'Note' field in the Properties panel.

Performing measurements

Measurement module:

- **snapping** possible – click on a point
 - within search window (semi-transparent square)
 - to min, max, or gradient (min or max)

Snapping example



Performing measurements

Measurement module:

- **editable properties:**
 - snapping
 - text (title and note)
 - callout and shape properties
 - measure points (colors, font, etc.)

The screenshot shows a settings panel for the measurement module, divided into four sections:

- Snapping:** Includes a checked checkbox, a width slider set to 30, a snap type dropdown set to 'chocolate-bar.am', and a 'Snap-it' trigger button.
- Text:** Includes a checked checkbox, a 'Title' field with 'Line', and an empty 'Note' field.
- Callout Properties:** Includes checked checkboxes, font selection for title and note (MS Shell Dlg 2, 8 pt.), color selection for foreground and background, 'Current View' checkboxes for 'visible' and 'minimized', and a 'Decimal Places' field set to 2.
- Shape Properties:** Includes a checked checkbox, a 'Point' dropdown set to 1, three coordinate input fields (1.5512, 11.488, 17.64), an 'Export' button labeled 'Export as new data', a 'Width' slider set to 0.50, and a 'Color' field with a pink color swatch.

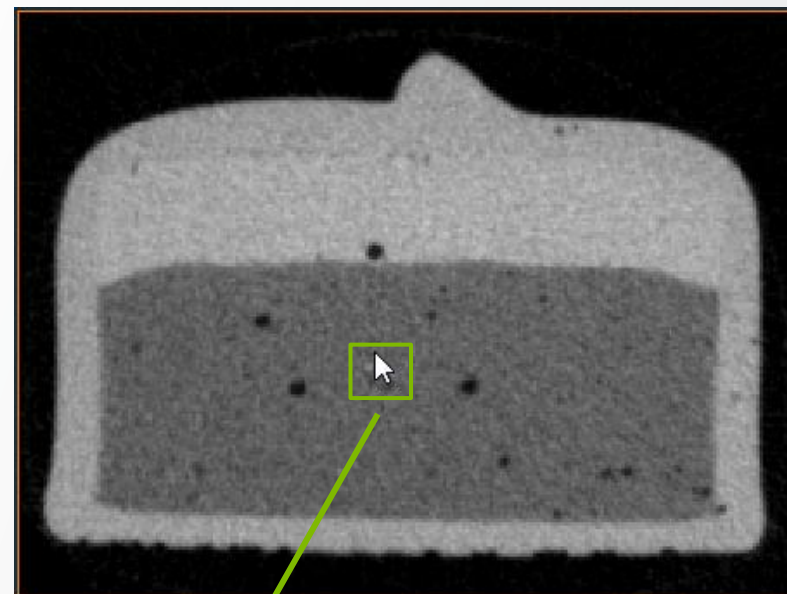
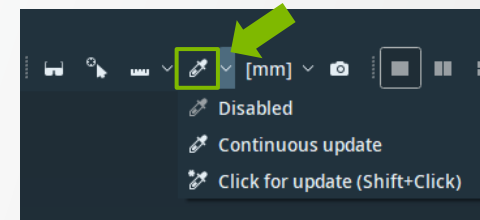
Select point to modify (#1 or #2)

Edit x, y, z coordinated of the selected point

Probing data value

Quick Probe

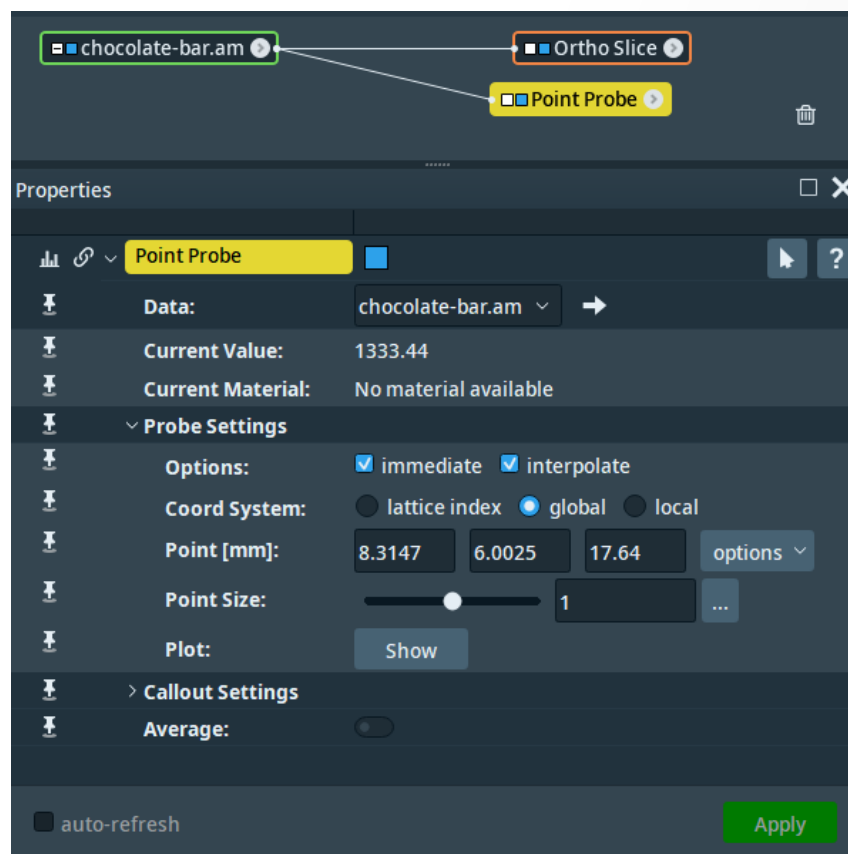
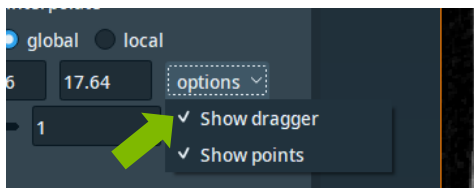
- show value of data at mouse position (interactive mode should be on)
- works with e.g. Slice, Ortho Slice, and Volume Rendering
- 2 modes:
 - Continuous update
 - Click for update (Shift + Click)
- prefer “Click for update”
- value is shown in status bar



Probing data value

Point Probe

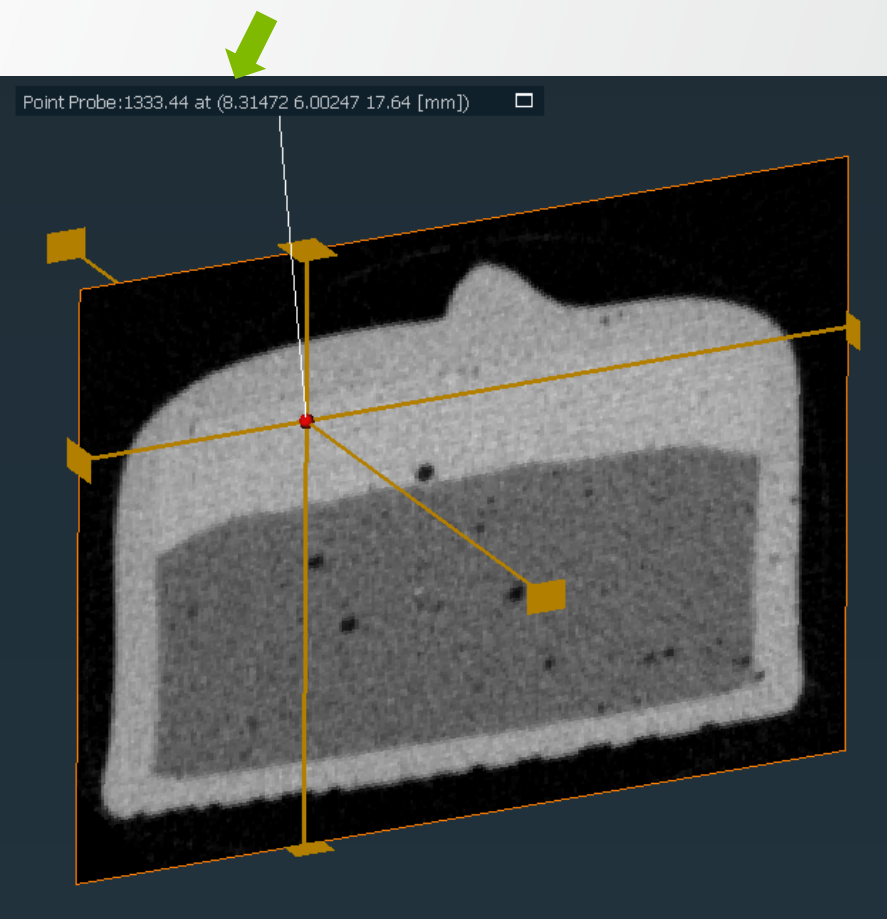
- get callout with position and value
- select Point Probe and click with middle mouse button to pick a location, or move the handles
- works with e.g. Ortho Slice, Slice, Voxelized Rendering
- editable callout settings
- local averaging
- hide dragger:



A screenshot of the software interface showing the Point Probe settings panel. The panel is titled 'Properties' and contains the following settings:

- Point Probe** (selected)
- Data:** chocolate-bar.am
- Current Value:** 1333.44
- Current Material:** No material available
- Probe Settings**
 - Options:** immediate interpolate
 - Coord System:** lattice index global local
 - Point [mm]:** 8.3147 6.0025 17.64
 - Point Size:** 1
 - Plot:** Show
- Callout Settings**
 - Average:**

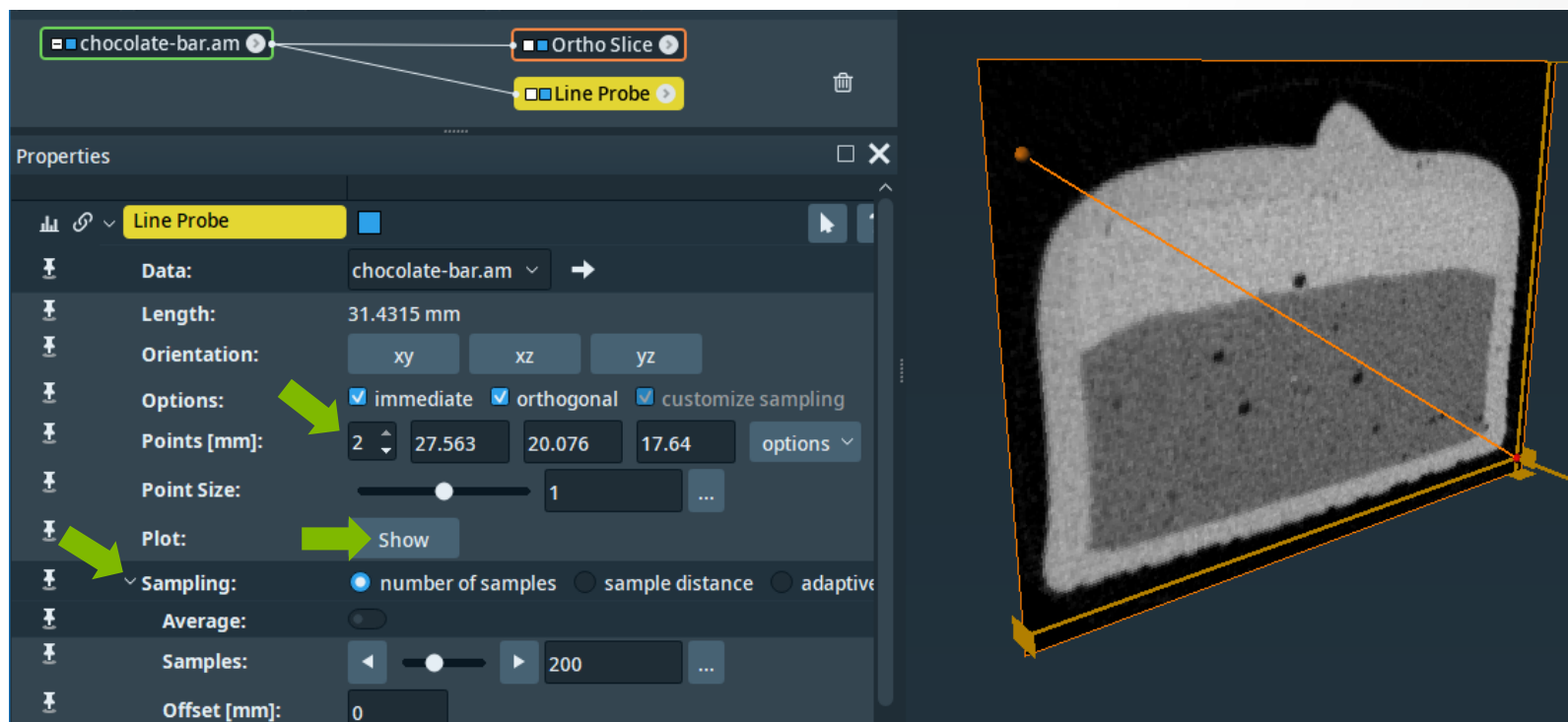
At the bottom of the panel, there is an 'auto-refresh' checkbox and an 'Apply' button.



Probing data value

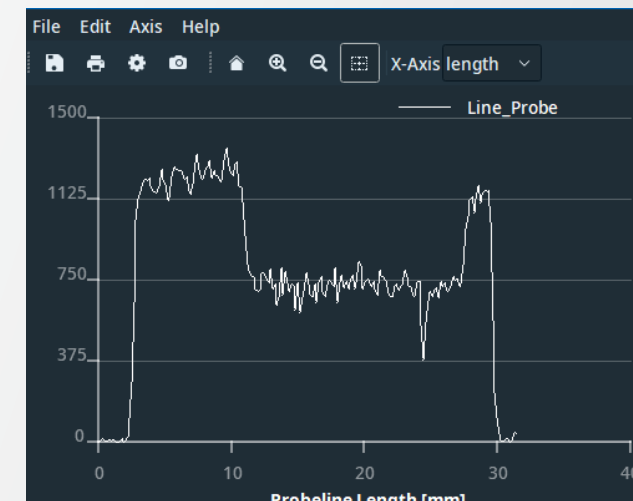
Line Probe (2D and 3D)

- evaluate the data-values along a straight line
- select point to modify (#1 or #2) – to change the coordinates in the text boxes or
- click with middle mouse button to pick new location or use handles to position the points
- for arbitrary orientation de-select “orthogonal”



Display line-profile in plot window:

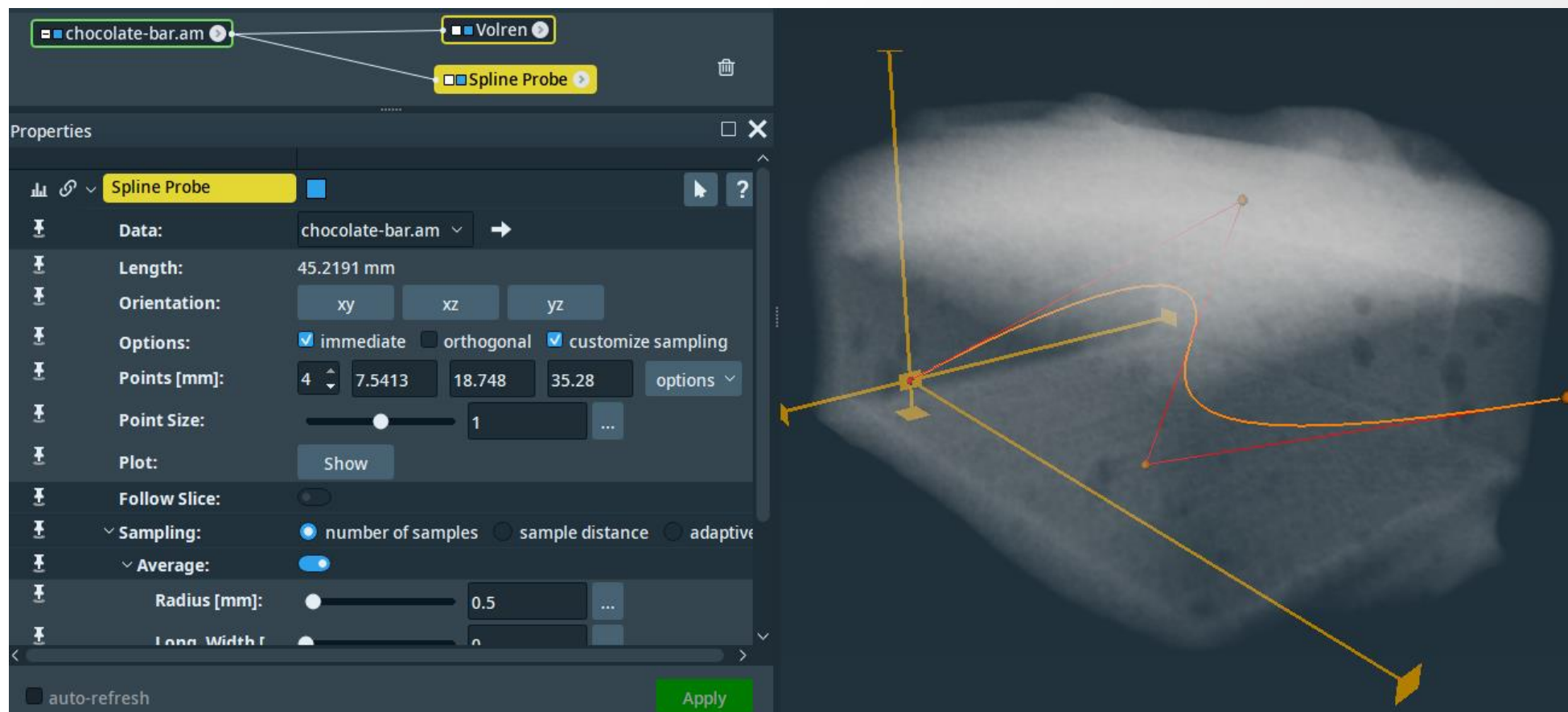
- adjust number of sample-points
- possibility for local averaging



Probing data value

Spline Probe

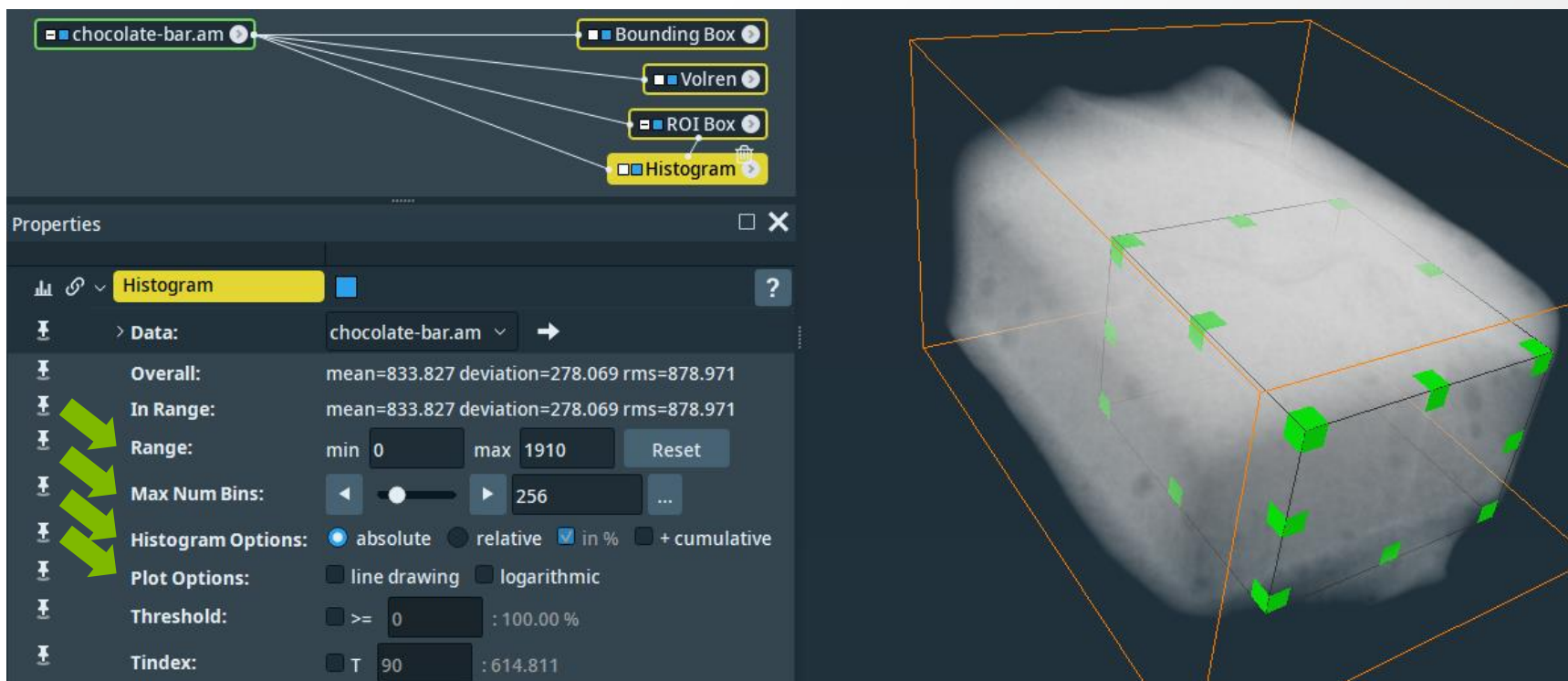
- similar to Line Probe, but:
 - arbitrary number of control points
 - sampling along smooth, curved Spline



Probing data value

Histogram

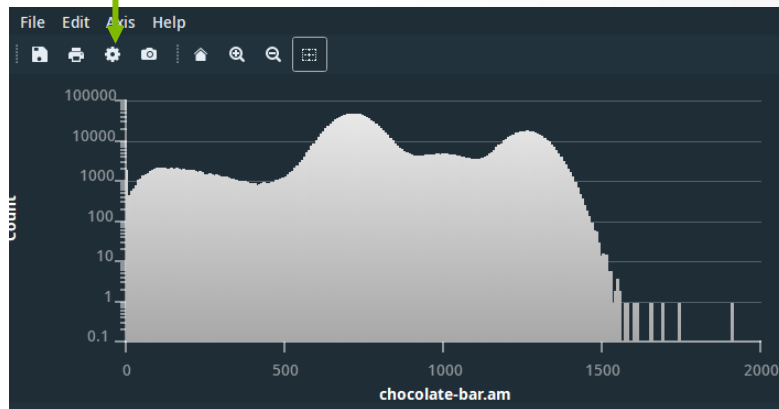
- distribution of values in the data-set
- optionally limited to ROI or mask
- adjust settings:
 - range
 - number of bins
 - absolute/relative counting
 - linear/logarithmic Y-axis



Probing data value

Histogram

- further settings:
 - axis control for X and Y:
 - range
 - number format
 - tick-marks
 - linear/log
 - labels
 - ...



axis

X Y

Range: 0.1 100000 Auto Nice Nums

Ticks: 5 1 Nice Nums Format: %g

Subticks: 0

Intersection: Min Mid Max 0.0 Box Show Ticks On Box

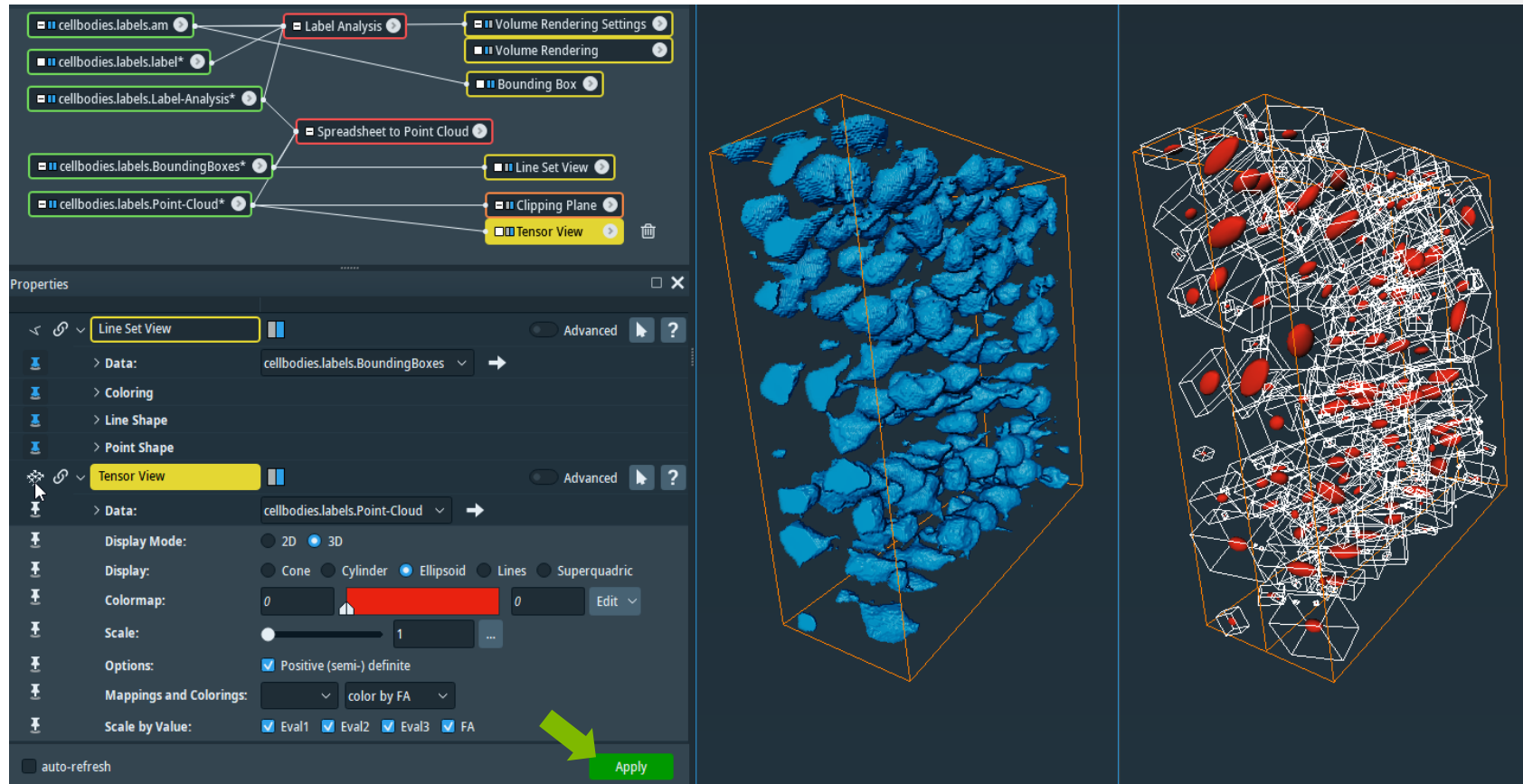
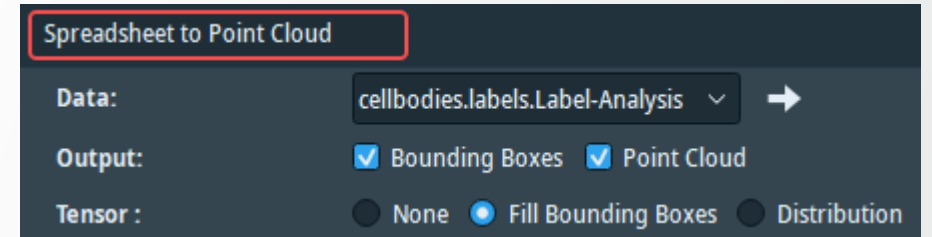
Type: Lin Log is Visible Zoom and Pan allowed

Attributes: Color: Linewidth: 2 Arrow

Label: Count Position: Center Color:

Spreadsheet visualization

- Plot Spreadsheet
- Histogram
- Spreadsheet To Point Cloud + Point Cloud View for the display
 - e. g. create **bounding-box** information and **orientation tensors**



Spreadsheet visualization

- Spreadsheet To Point Cloud + Point Cloud View for the display
- e. g. point cloud as **sphere** visualization

Spreadsheet to Point Cloud

Data: cellbodies.labels.Label-Analysis →

Output: Bounding Boxes Point Cloud

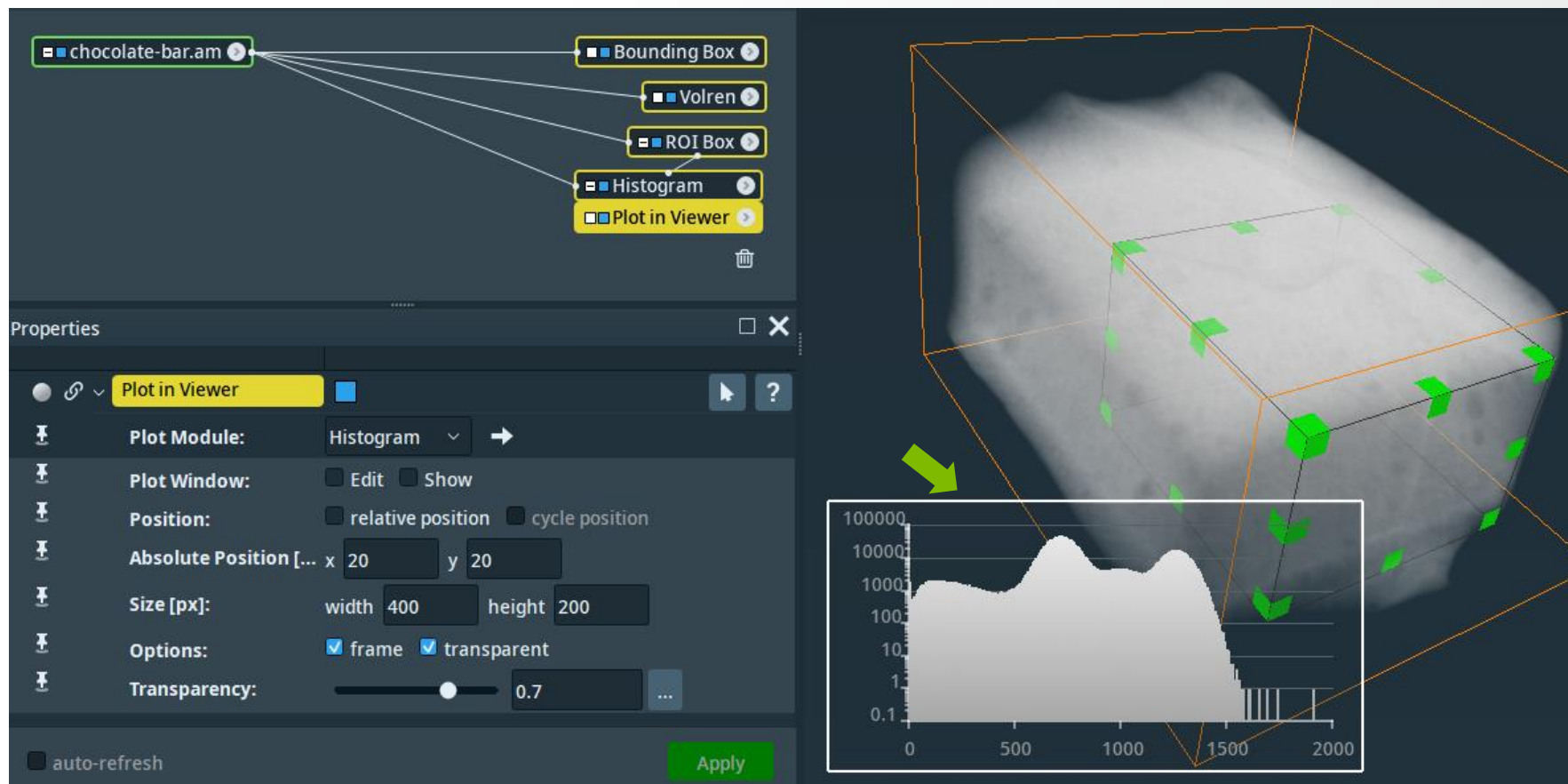
Tensor: None Fill Bounding Boxes Distribution

The screenshot displays a software interface for 3D visualization. On the left, a workflow diagram shows data sources like 'cellbodies.labels.am', 'cellbodies.labels.label*', 'cellbodies.labels.Label-Analysis*', and 'cellbodies.labels.Cloud*' feeding into 'Label Analysis' and 'Spreadsheet to Point Cloud'. The 'Spreadsheet to Point Cloud' node is highlighted with a red box. Below the diagram is a 'Properties' panel for the 'Point Cloud View' node. The 'Data' is set to 'cellbodies.labels.Cloud'. The 'Colormap' is a gradient from 0 to 7500. 'Options' include 'spheres' (checked), 'opaque' (checked), and 'bonds' (unchecked). 'Sphere Scale' is set to 0.5. 'Action' buttons include 'Export', 'Select', 'Reset', and 'Undo'. 'Filter' is disabled. 'Scale Spheres' is enabled, and 'Scale Data' is set to 'EqDiameter [EqDiameter]'. An 'Apply' button is at the bottom right. On the right, two 3D views are shown: the left one is a blue point cloud, and the right one is a sphere visualization with a color scale from 0 to 7500.

Displaying plots in the main viewer

Normally, all kinds of plots are displayed in a separate viewer window.
With **Plot In Viewer**, plots can be displayed in the main viewer window(s).


- can be attached to:
 - Histogram
 - Point Probe
 - Line Probe
 - Spline Probe
 - Plot Spreadsheet
- options:
 - position
 - size
 - transparency
 - frame

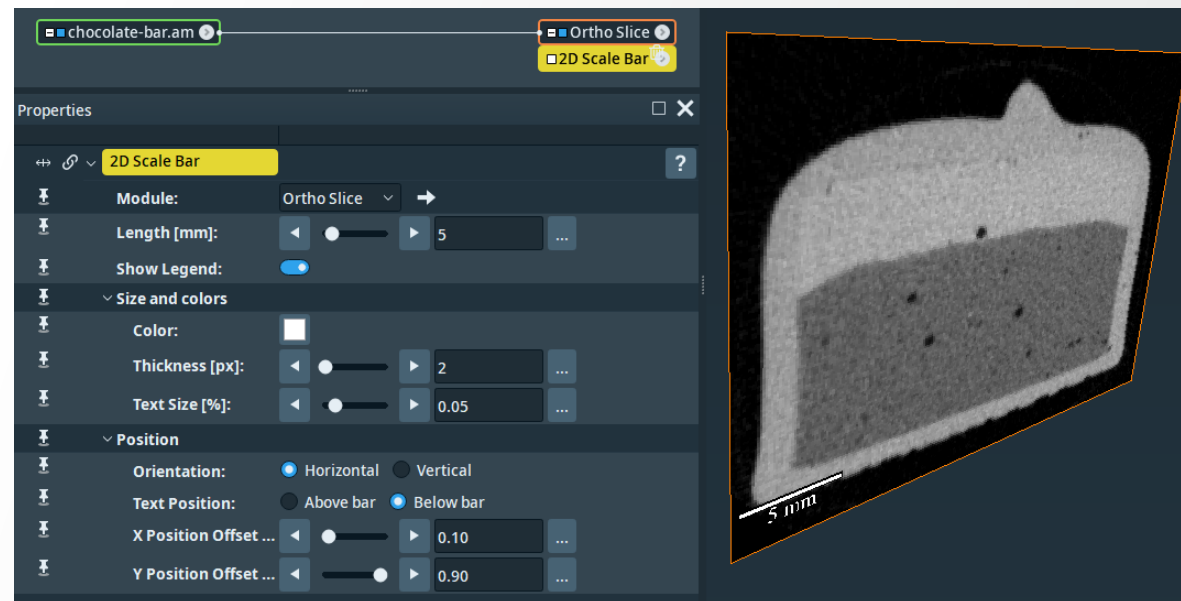


Annotation: Scale Bar and 2D Scale Bar


There are two types of scale-bars available:

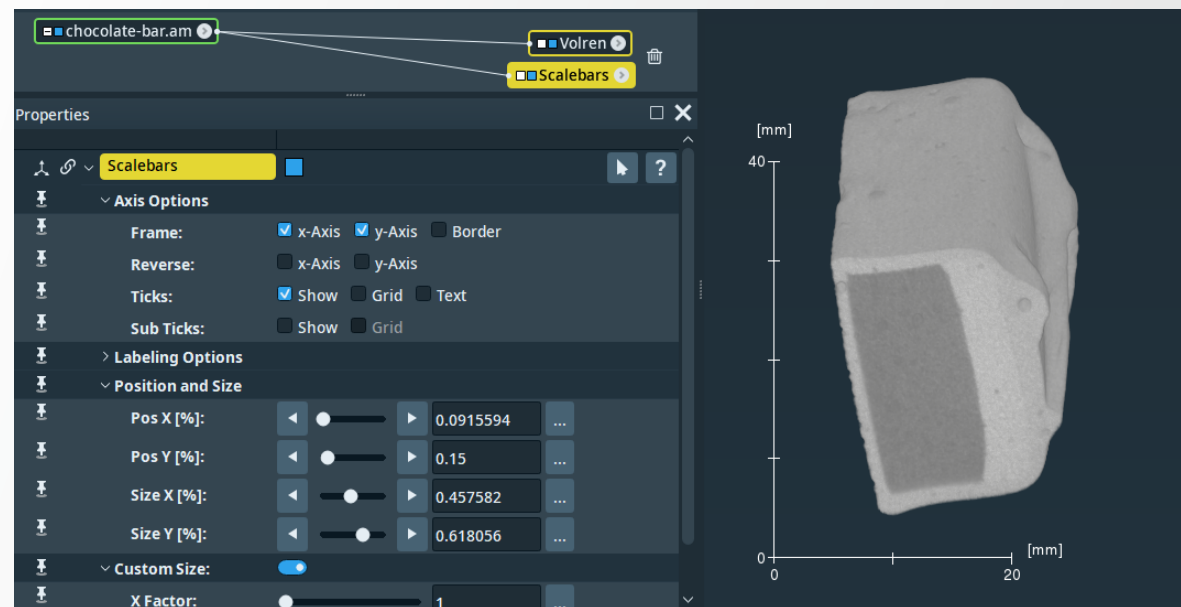
2D Scale Bar

- attached to a slice object
- correct also in perspective () view!
- options: length, position, color, ...



Scale Bar

- located in the 3D viewer
- invoked via click on background and “Create object → Annotations → Scalebars”
- only meaningful in orthographic ( , parallel) view!
(because of perspective shortening)
- options: length, position, color, label, font, ticks, ...



Annotation: Colorbar

Attach **Colormap Legend** to the display module.

- options:
 - size
 - vertical
 - background
 - font
 - title
 - custom text
 - Histogram

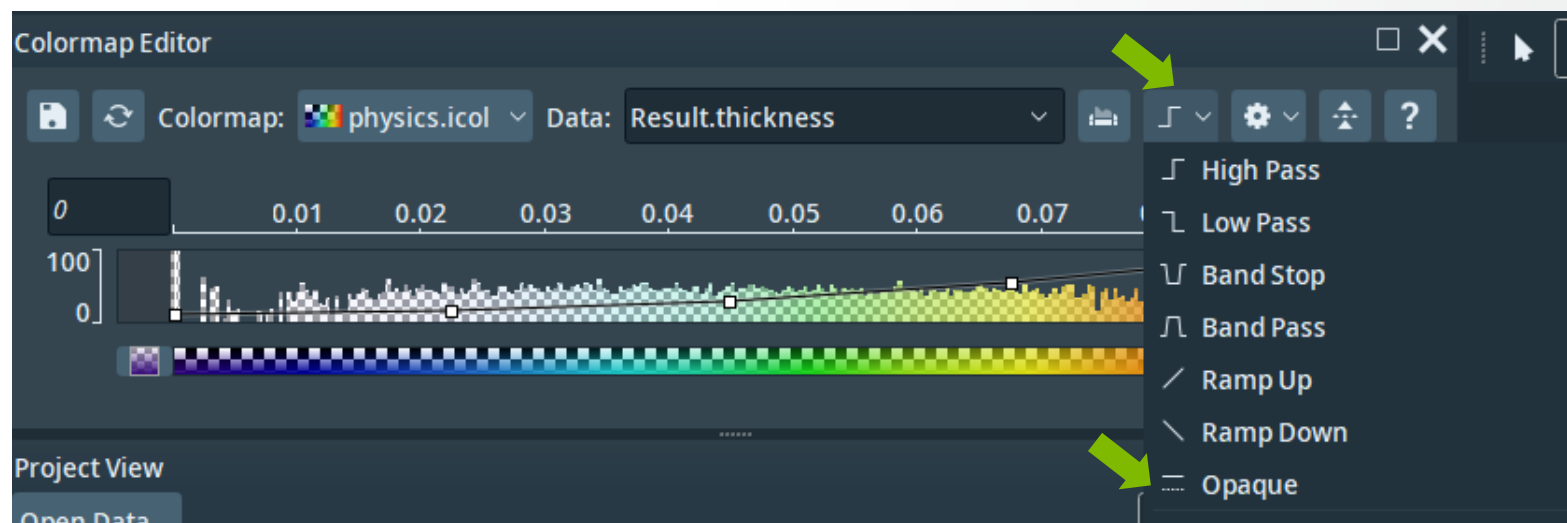
Tip: set **alpha=0** to hide the histogram

The screenshot displays the software interface for attaching a Colormap Legend. On the left, a flowchart shows the data flow: 'Arithmetic' and 'Thickness Map' feed into 'Result*', which then feeds into 'Result.thickness*'. This 'Result.thickness*' feeds into 'Ortho Slice', which then feeds into 'Color Wash'. The 'Color Wash' module is connected to the 'Colormap Legend' annotation. Below the flowchart is the 'Properties' panel for the 'Colormap Legend' annotation. The 'Data' is set to 'Color Wash'. The 'Options' section includes checkboxes for 'custom text', 'vertical', 'rel. size', 'transp. bg' (checked), and 'font'. The 'Position' is set to x=85, y=70. The 'Size [px]' is length=180, width=18. The 'Annotation' section has 'Custom Text' set to 'ow 0.0442686/Medium 0.0885373/High' and 'Title' is empty. The 'Histogram' section has 'Histogram Options' set to 'Overlay', 'Color' is selected, 'Color2' is white, and 'alpha' is 0.80. A green arrow points to the 'alpha' field. On the right, a heatmap visualization shows a complex structure with a color scale at the bottom ranging from 0 (dark purple) to 0.0885373 (yellow), with 0.0442686 marked in the middle. A small histogram is visible at the bottom of the heatmap.

Annotation: Colorbar

If you want to get rid of the checkerboard-pattern:

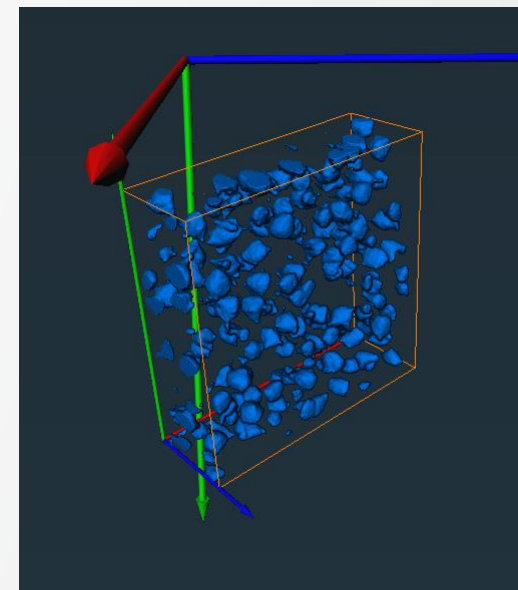
- in the display-module's (e.g. Color Wash) colormap port:
select "Options → Edit colormap"
- in the Colormap Editor:
set transparency to "Opaque"



Annotation: Axes, Caption

Axes

- visualization of global coordinate system:
 - no data-set connected
 - invoked via click on background and “Create object → Annotations → Axes”
- visualization of local coordinate system:
 - connected to a data object
 - invoked via the object’s context menu (“Annotate → Axes”)
- default coloring convention: X: red, Y: green, Z: blue



Caption

- any text in the viewing plane of the viewer
- invoked via click on background and “Create object → Annotations → Caption”
- options: position, text, color, font

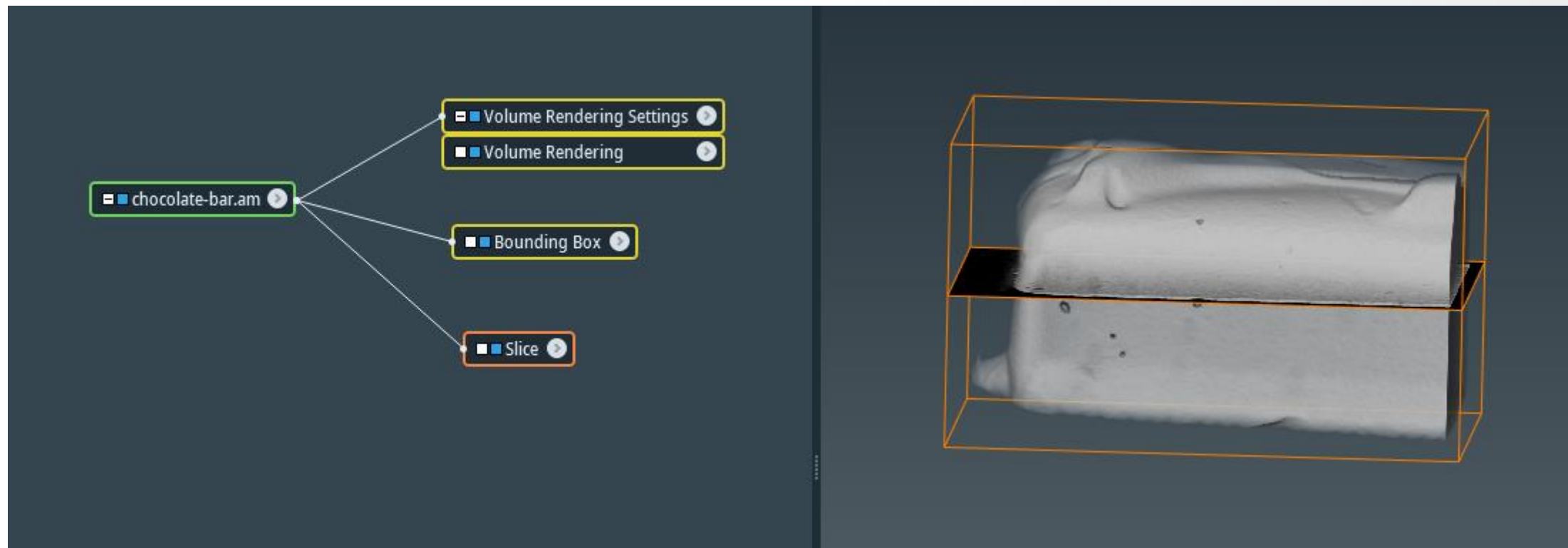


Data registration and alignment



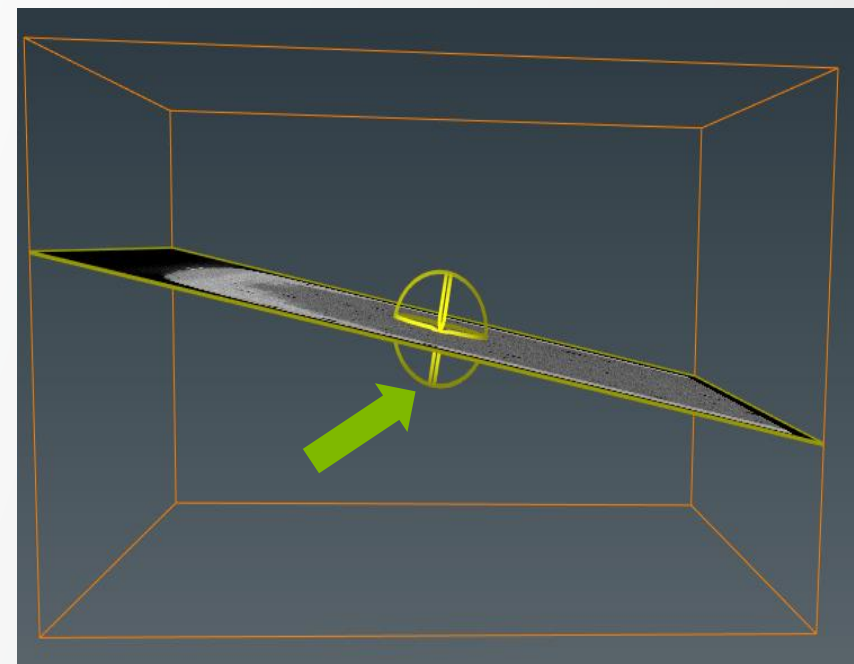
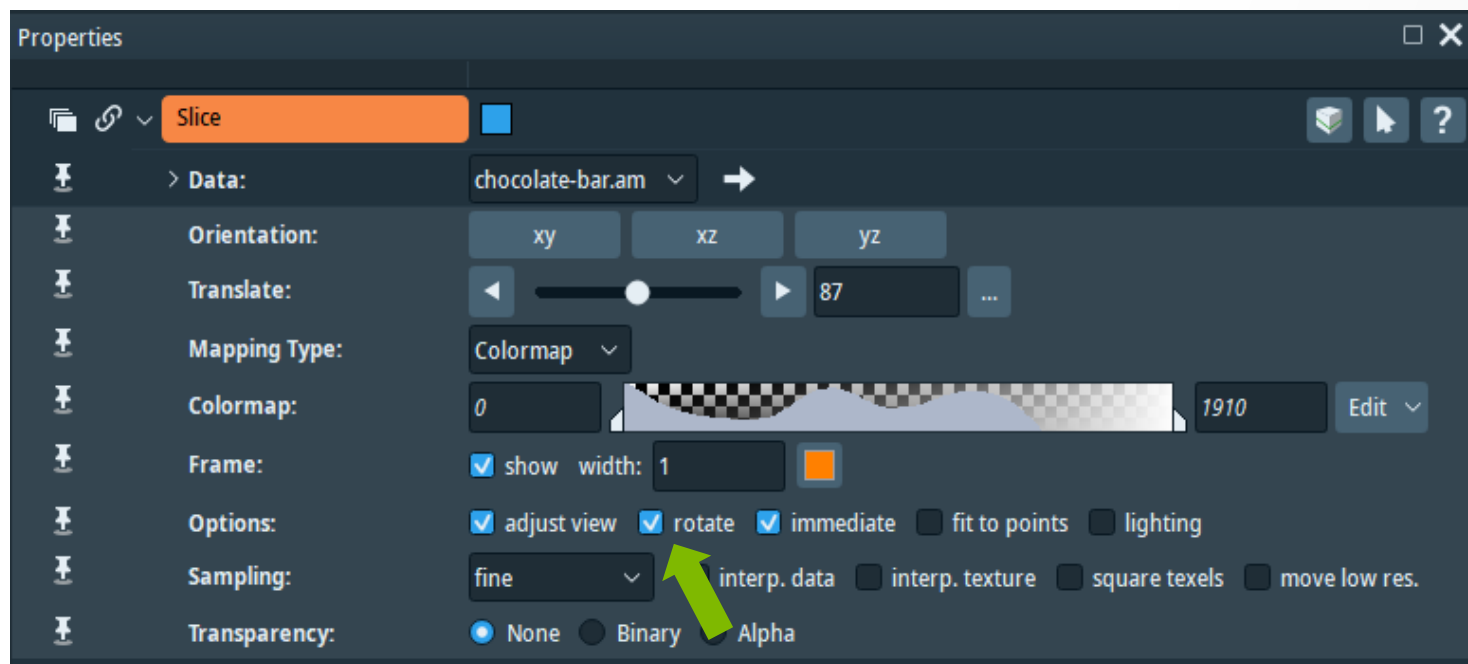
Alignment to an oblique plane: example

Load `chocolate-bar.am` then attach `Volume Rendering`, `Bounding Box` and `Slice` to the dataset (oblique view).



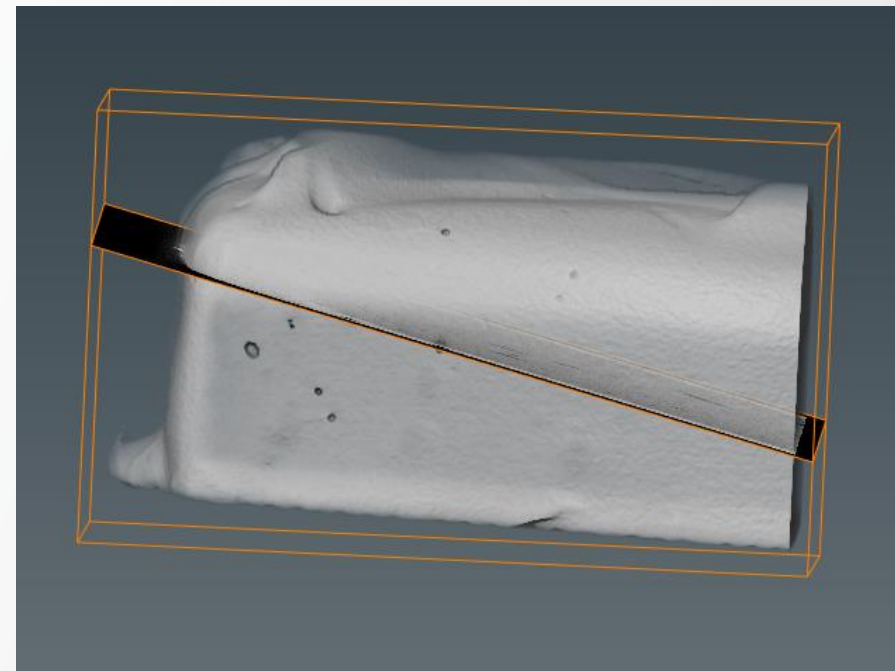
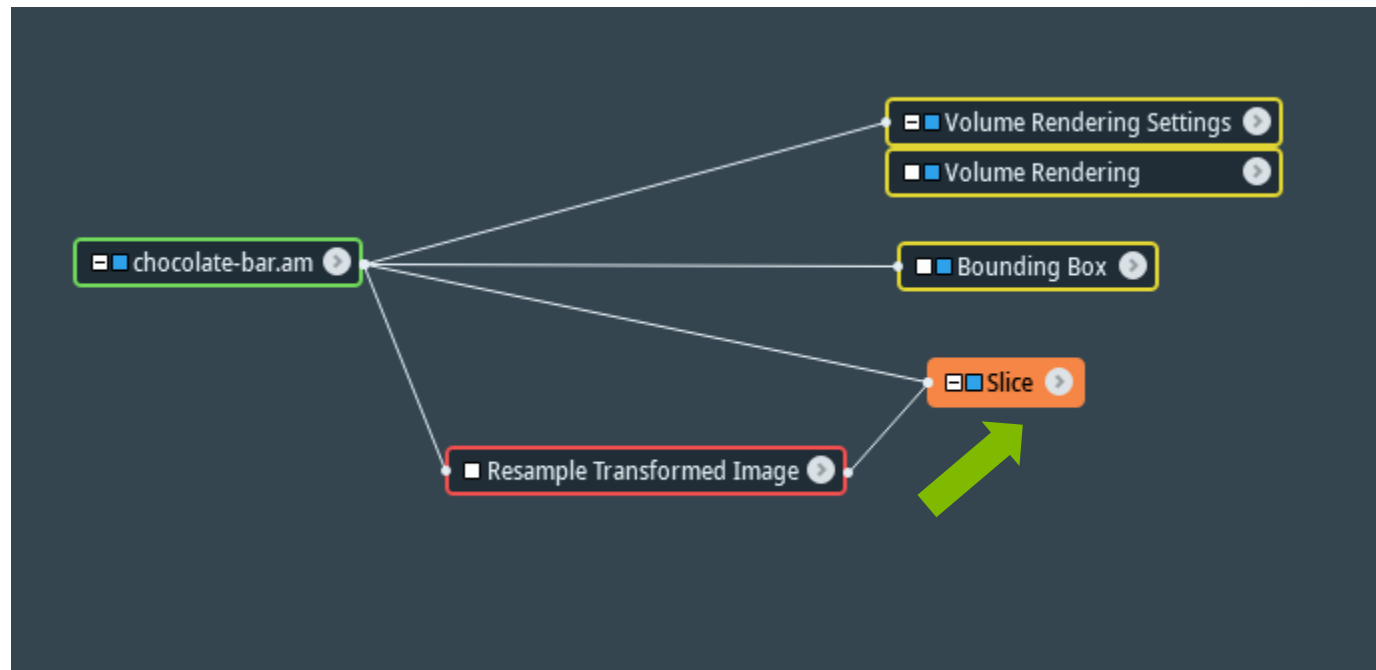
Alignment to an oblique plane: example

Rotate **Slice** using rotate mode in **Slice** properties port (activate trackball) to rotate to the desired tilt angle.



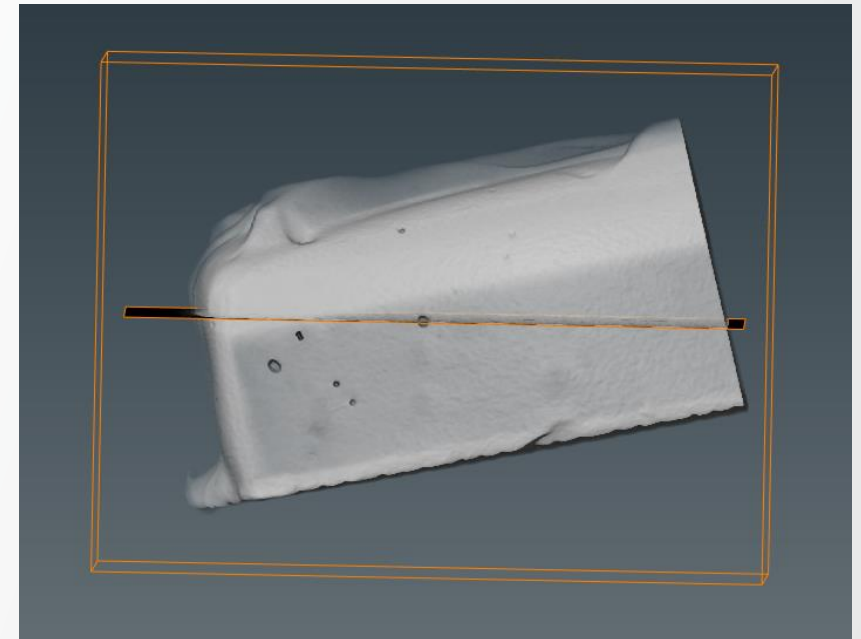
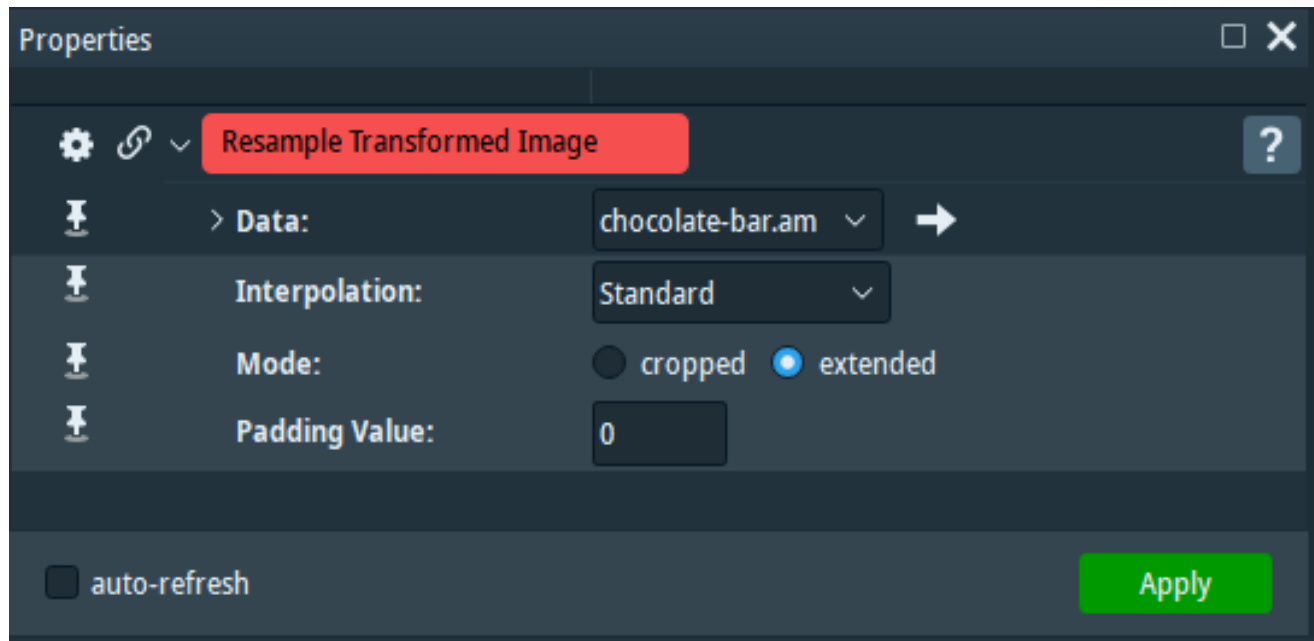
Alignment to an oblique plane: example

Attach **Resample Transformed Image** to **chocolate-bar.am** and set reference to **Slice**.



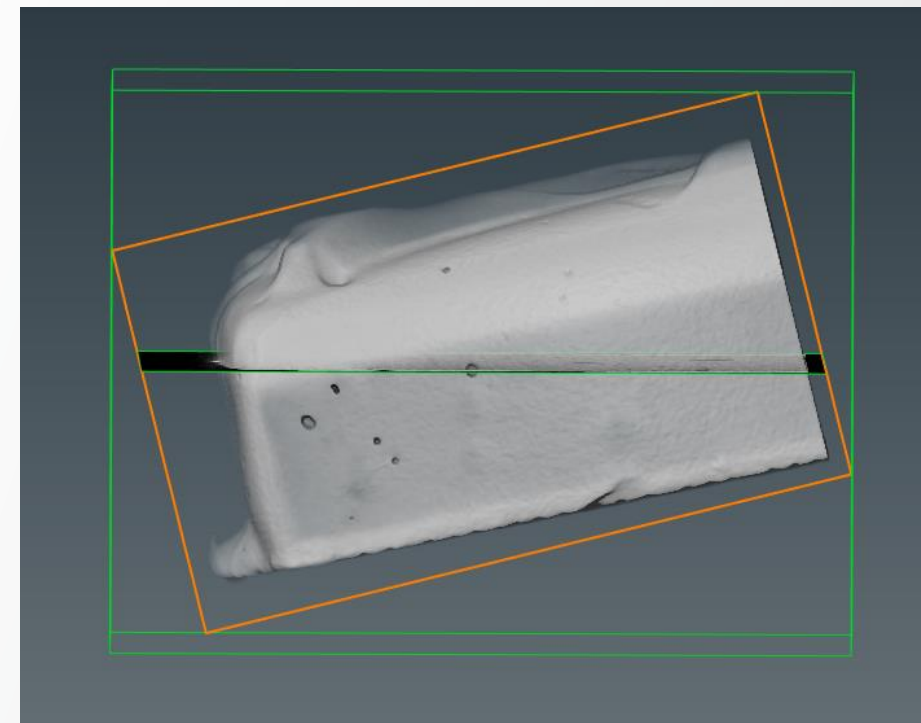
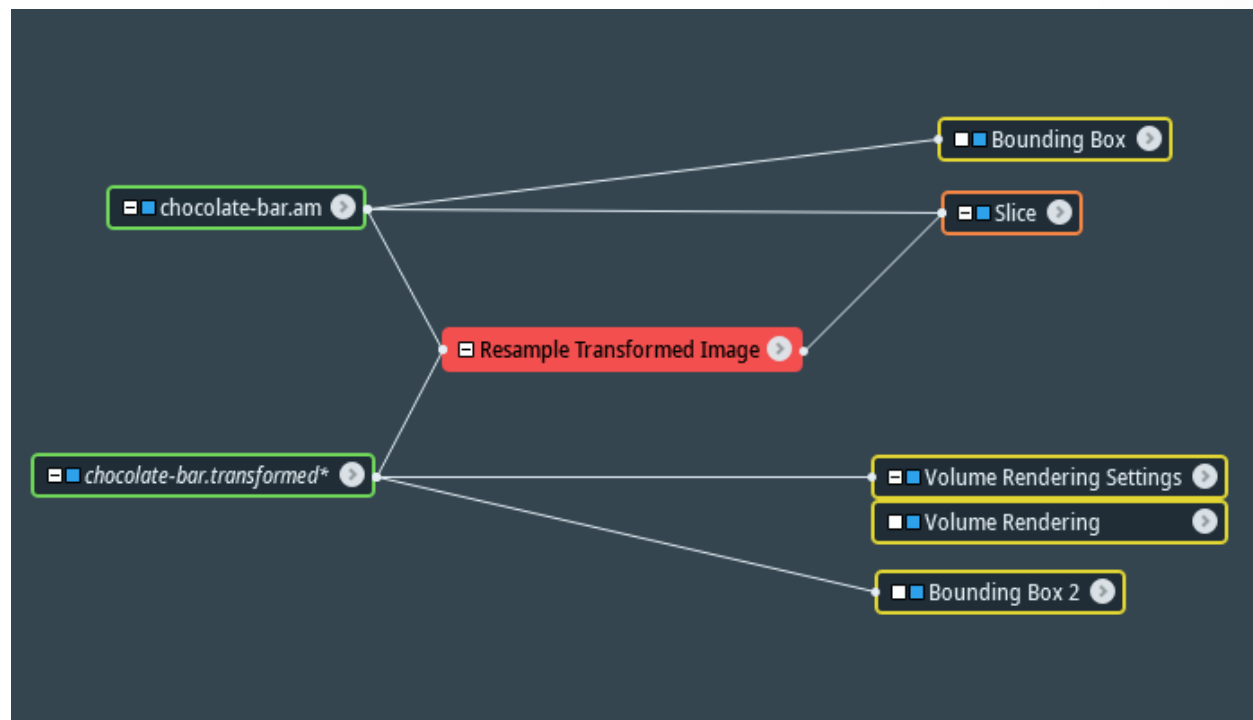
Alignment to an oblique plane: example

At **Resample Transformed Image** properties select Interpolation: Standard, Mode: extended then click **Apply**.



Alignment to an oblique plane: example

Attach another **Bounding Box** to **chocolate-bar.transformed** and visualize with **Volume Rendering**.
The transformed result is now aligned with **Slice** (in green).



Data registration: introduction

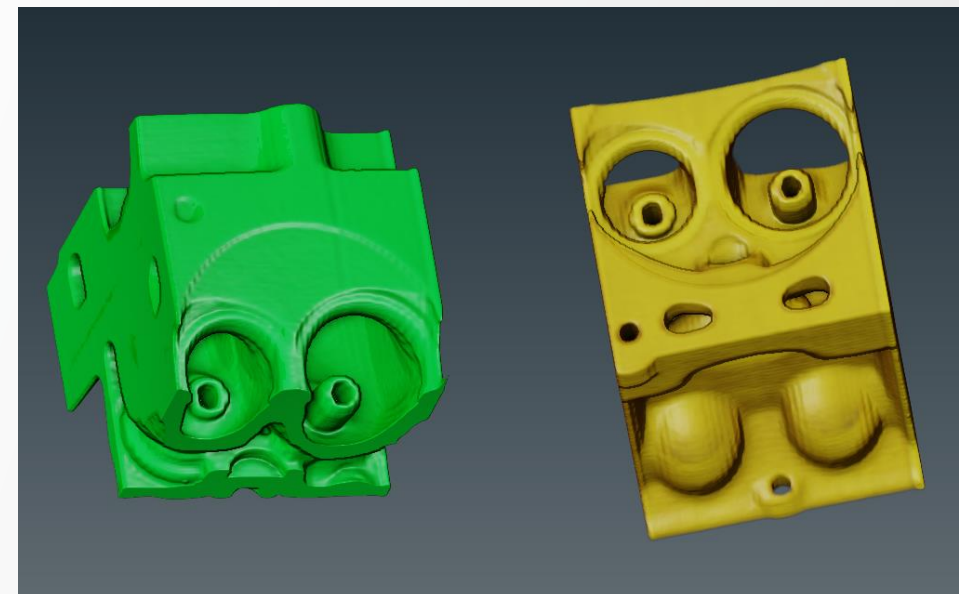
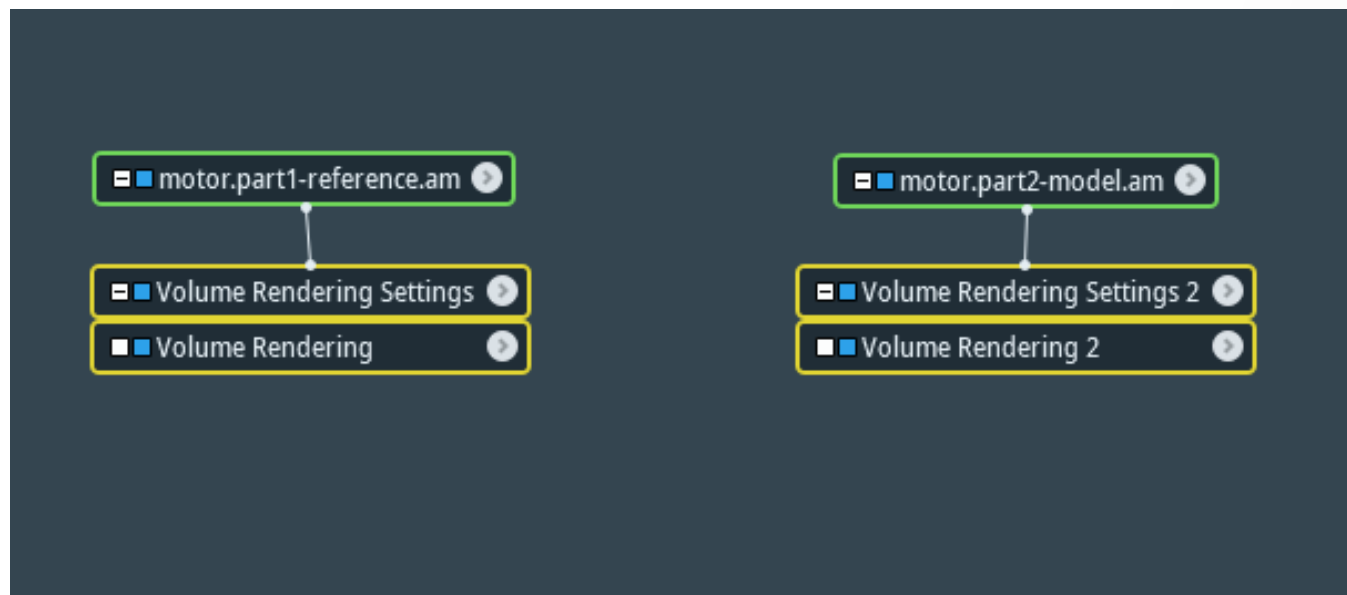
- General concepts
 - All datasets are positioned in 'physical' space
 - This position is control by a 'Transform'
- Registration
 - Optimization of the 'alignment' with respect to the degrees of freedom given by the 'transform'
 - Difficult mathematical problem, sensitive to the initialization
- Avizo can register:
 - Volume to volume (grayscale or label images)
 - Surface to surface
 - Using Linear transform: translation, rotation, optionally scaling and shearing

Data registration: introduction

- General concepts
 - All datasets are positioned in 'physical' space
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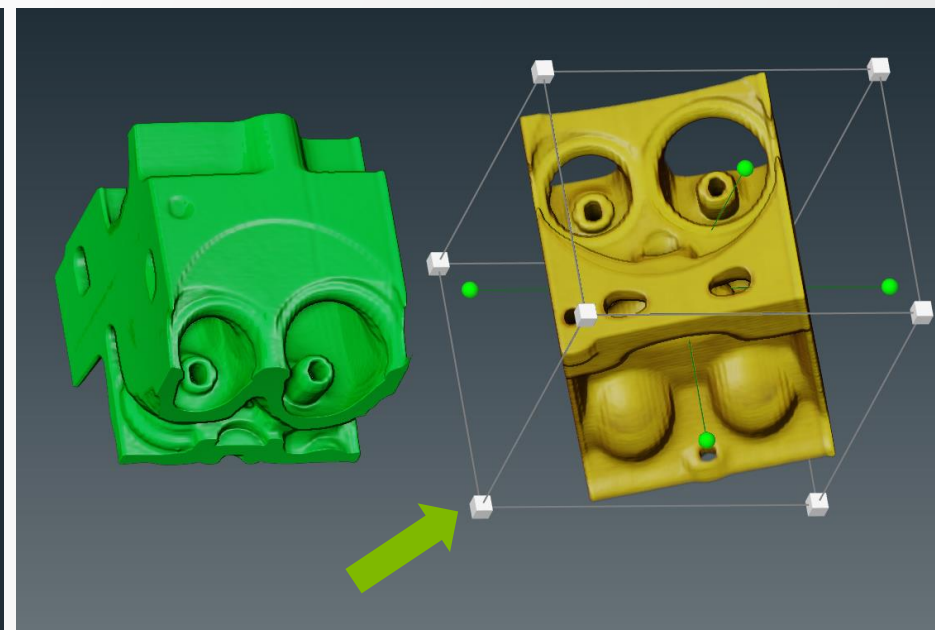
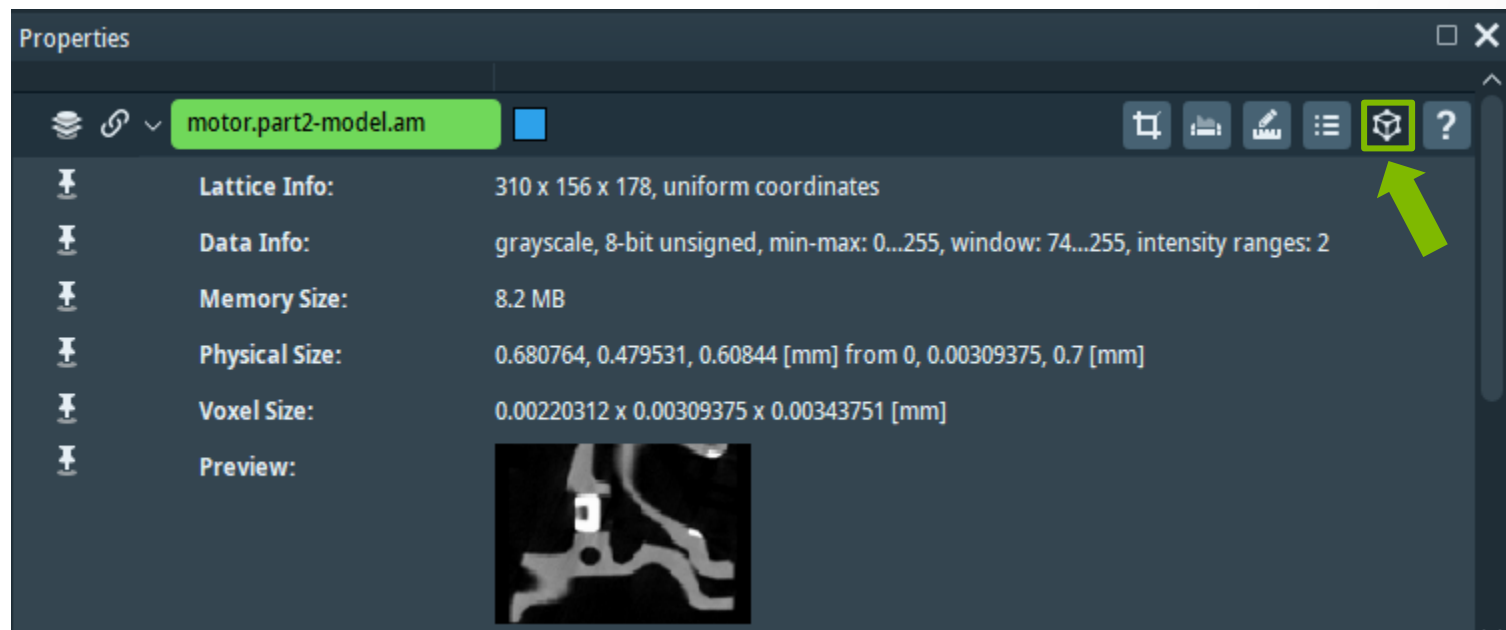
Data registration: Transform Editor module

Open [motor.part1-reference.am](#) and [motor.part2-model.am](#) (data -> registration) then attach **Volume Rendering** to each dataset.



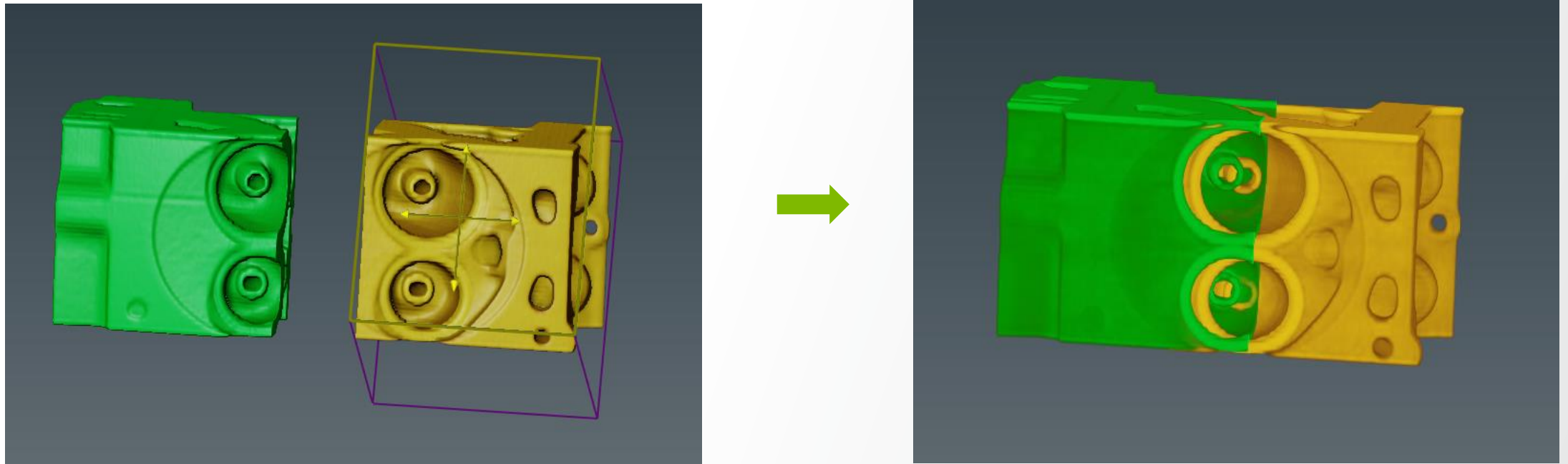
Data registration: Transform Editor module

In the properties window of `motor.part2-model.am`, activate **Transform Editor**, the transform box will appear.



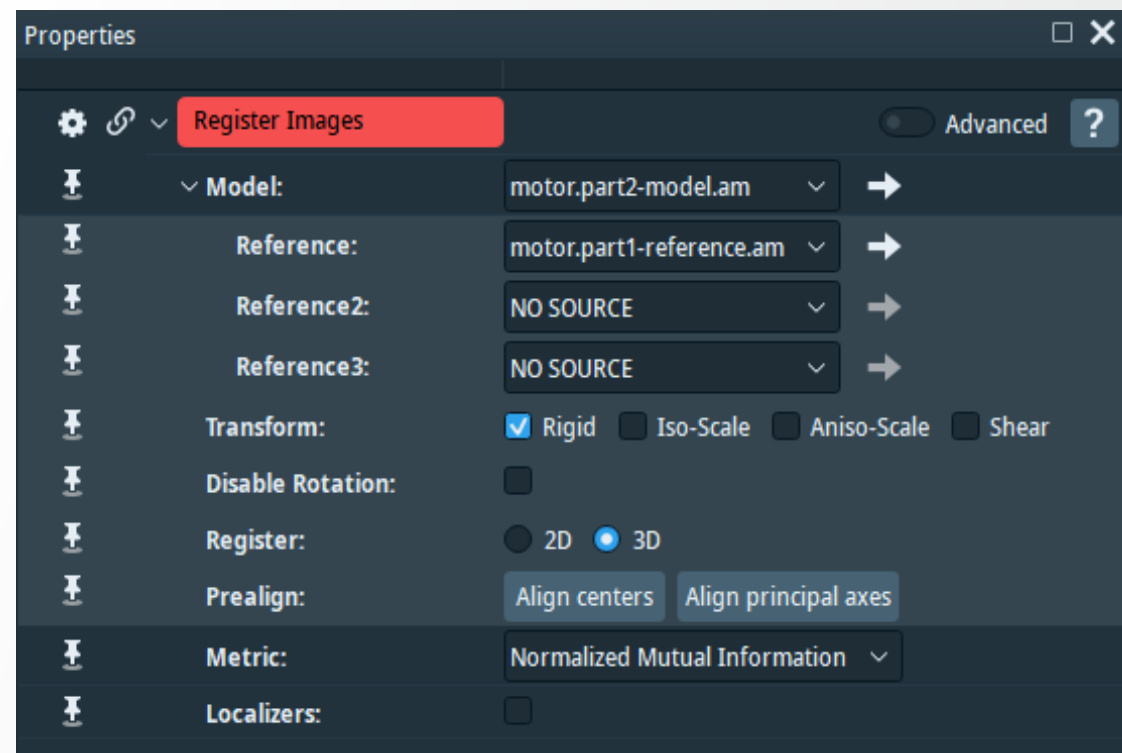
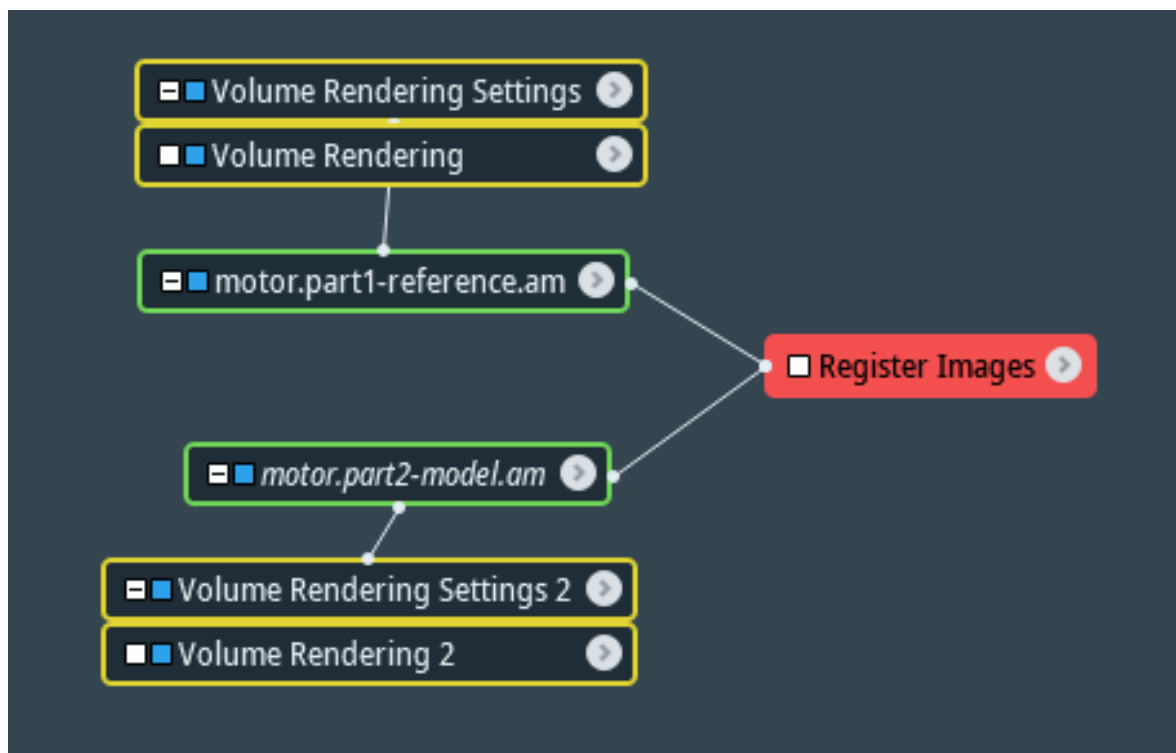
Data registration: Transform Editor module

Move the handle box and bring `motor.part2-model.am` (in yellow) to overlap with `motor.part1-reference.am` (in green) as much as possible.



Data registration: Register Images module

Attach **Register Images** to **motor.part2-model.am** and set the reference to **motor.part1-reference.am**.



- **Transform:** Rigid
- **Register:** 3D
- **Prealign:** Align centers & Align principal axes
- **Metric:** Normalized Mutual Information

Data registration: Resample Transformed Image module

Attach **Resample Transformed Image** to **motor.part2-model.am** to apply the transformation (otherwise the transformation will be available for visualization only).

The screenshot displays a software interface with a data flow diagram on the left and a 3D visualization of a motor part on the right. The data flow diagram shows a sequence of modules: 'Volume Rendering Settings' and 'Volume Rendering' are connected to 'motor.part1-reference.am'. 'motor.part1-reference.am' and 'motor.part2-model.am' are connected to 'Register Images'. 'motor.part2-model.am' and 'motor.part2-model.transformed*' are connected to 'Resample Transformed Image'. 'motor.part2-model.transformed*' is connected to 'Volume Rendering Settings 2' and 'Volume Rendering 2'. The 3D visualization shows a motor part with a green volume rendering on the left and a yellow volume rendering on the right, illustrating the transformation applied to the data.

Properties

Resample Transformed Image

- Data: motor.part2-model.am
- Interpolation: Standard
- Mode: cropped extended
- Preserve: Voxel Size Dimensions
- Padding Value: 0

Image fusion & stitching

Attach **Merge module** to **motor.part2-model.transformed** and set **motor.part1-reference.am** as a reference. Merge using standard interpolation with blend option.

The screenshot shows the 'Properties' panel for the 'Merge' module. The 'Data' section is expanded, showing the following settings:

Property	Value
Data	motor.part2-model.transformed
Lattice1:	motor.part1-reference.am
Lattice2:	NO SOURCE
Lattice3:	NO SOURCE
Lattice4:	NO SOURCE
Lattice5:	NO SOURCE
Lattice6:	NO SOURCE
Lattice7:	NO SOURCE
Lattice8:	NO SOURCE
Lattice9:	NO SOURCE
Lattice10:	NO SOURCE
Interpolation:	Standard
Padding Value:	0
Options:	<input checked="" type="checkbox"/> blend <input type="checkbox"/> use existing result

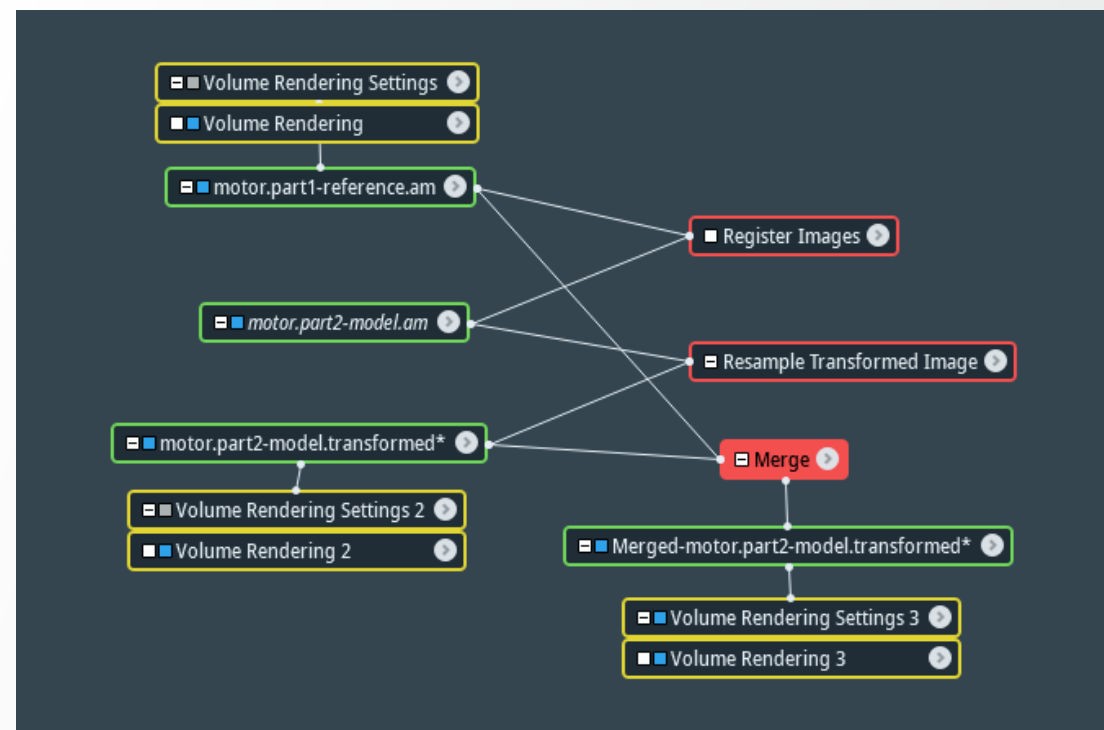
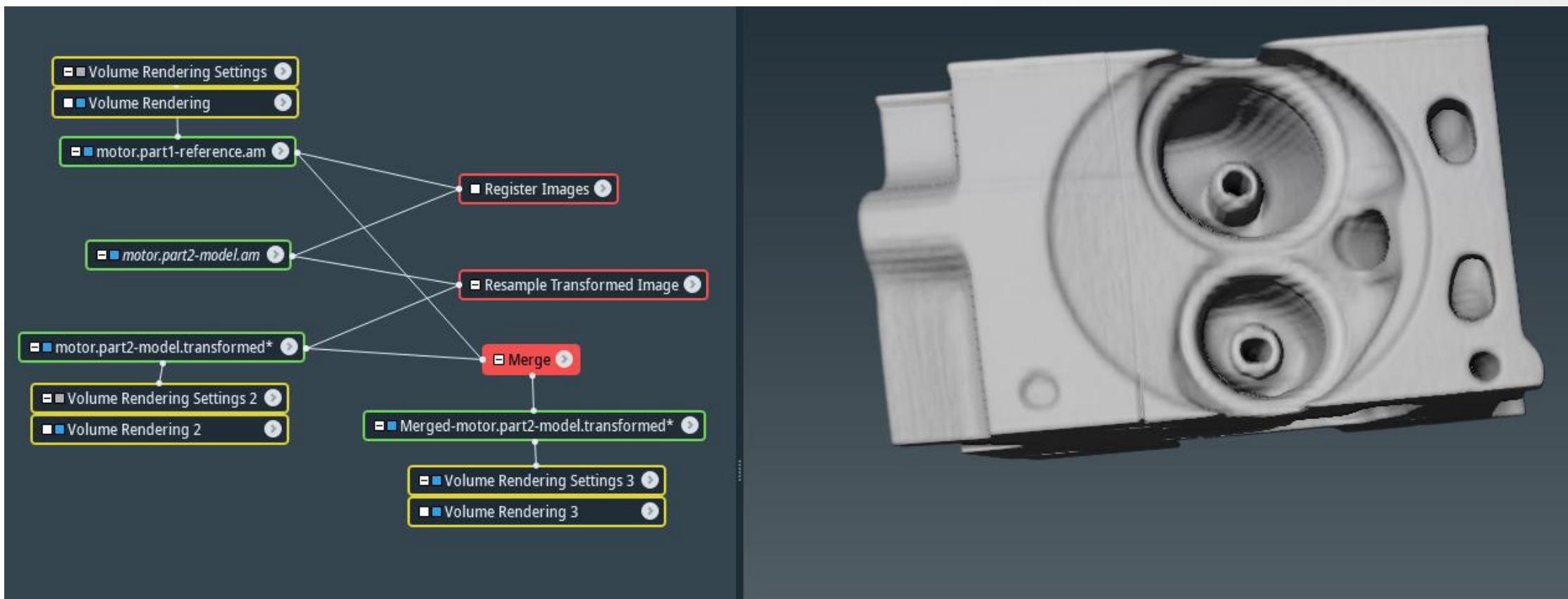
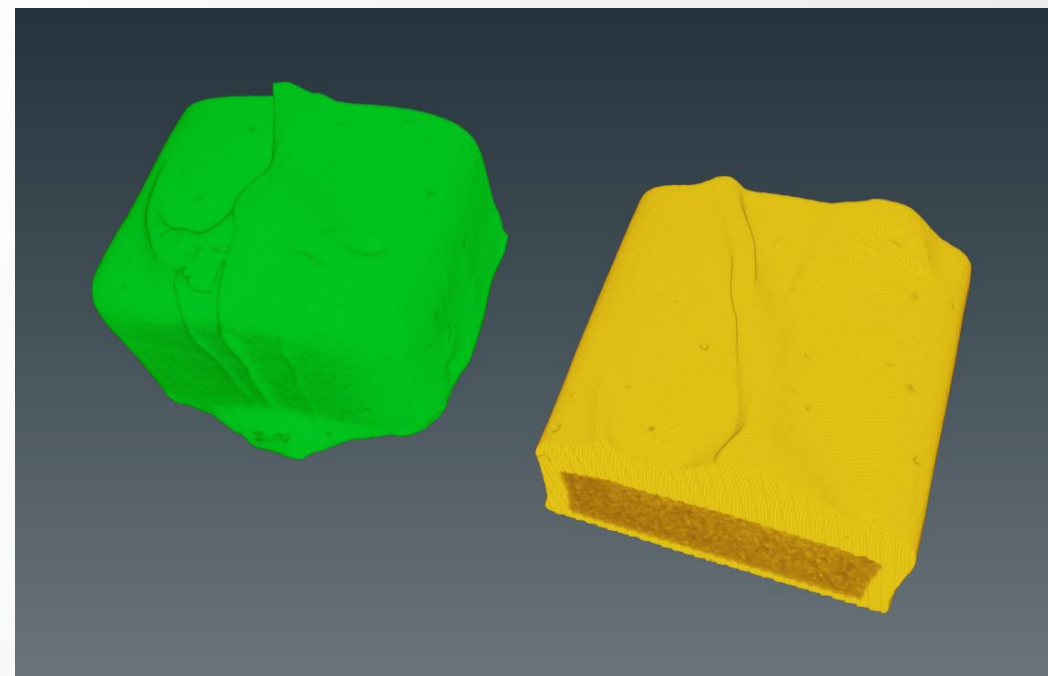
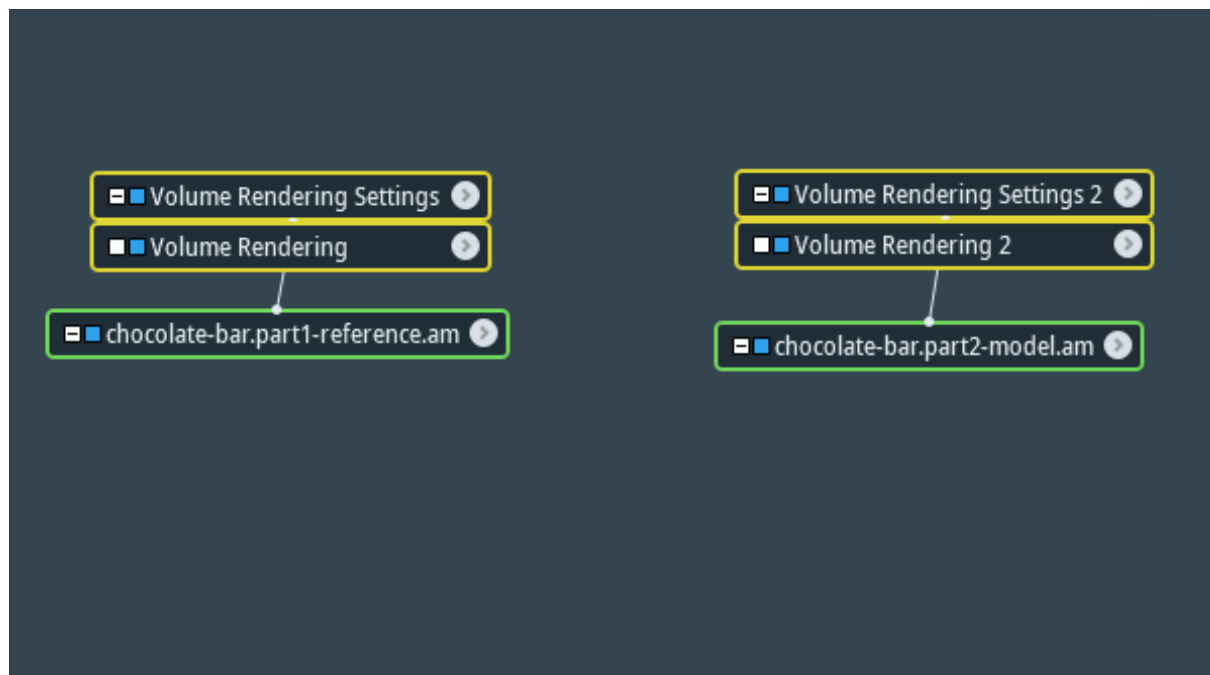


Image fusion & stitching



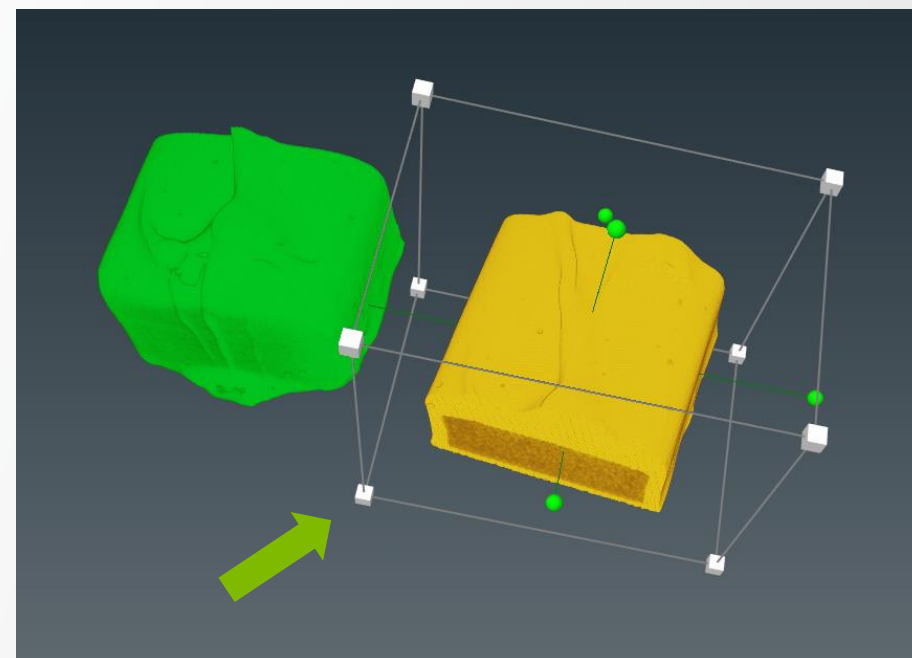
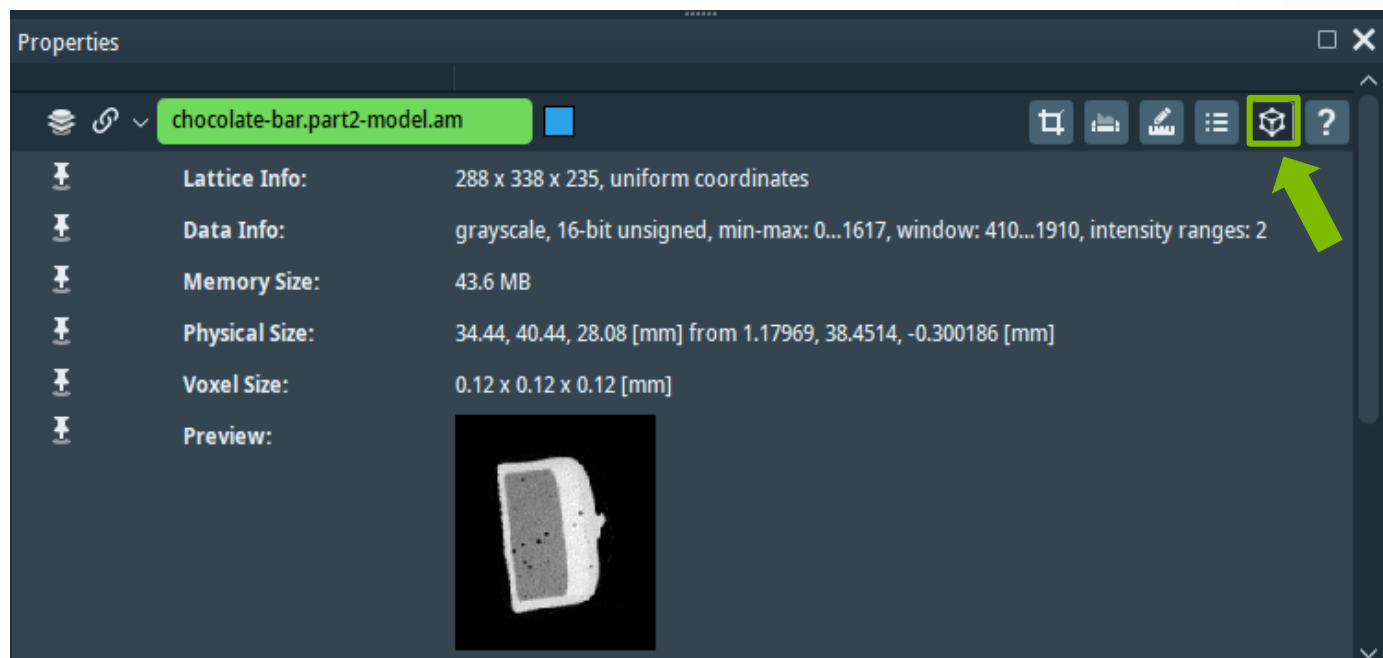
Data registration: Transform Editor module

Open `chocolate-bar.part1-reference.am` and `chocolate-bar.part2-model.am` (data > registration) then attach **Volume Rendering** to each dataset.



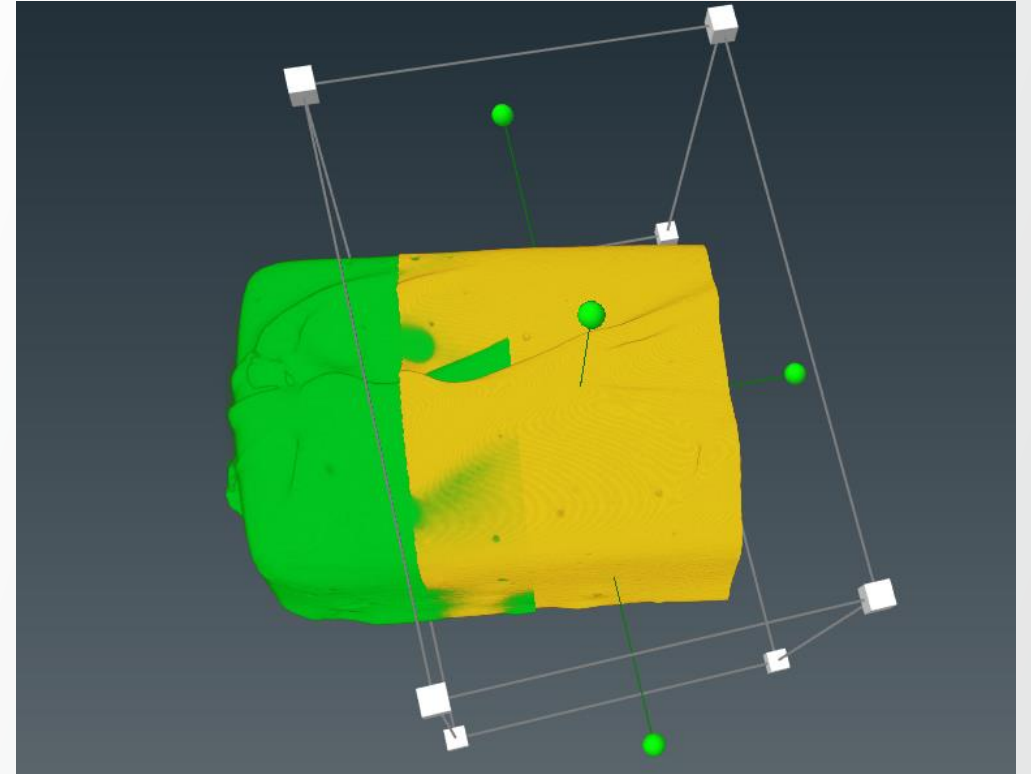
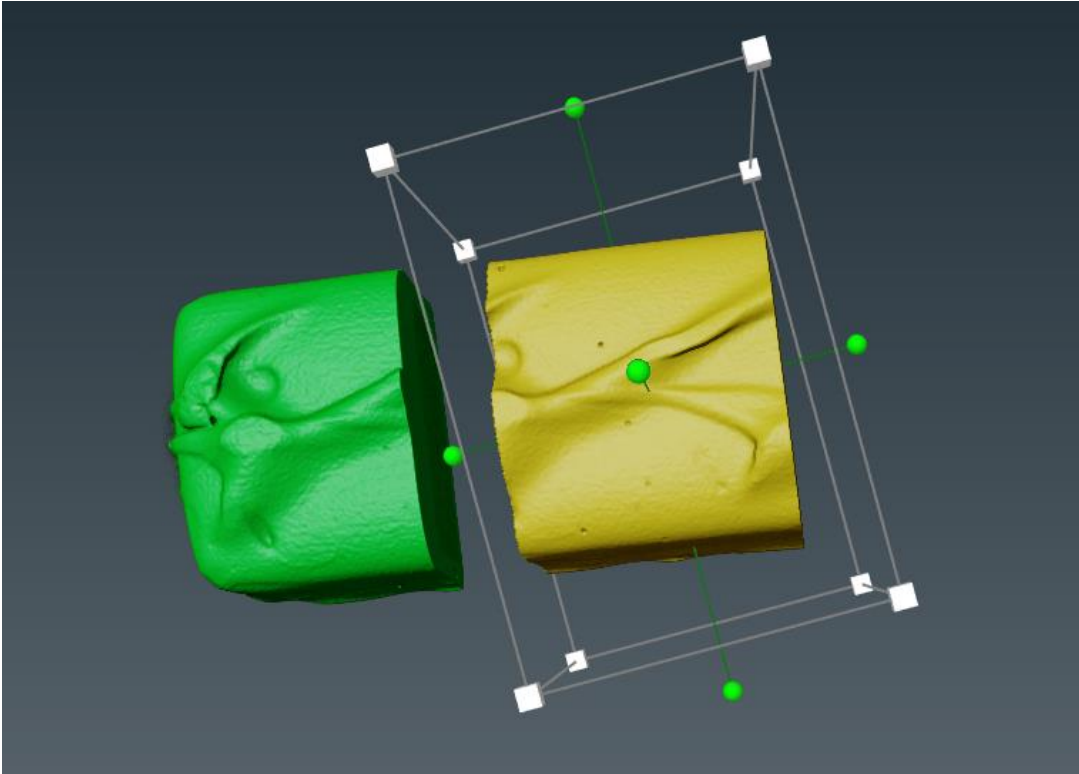
Data registration: Transform Editor module

In the properties window of `chocolate-bar.part2-model.am`, activate **Transform Editor**, the transform box will appear.



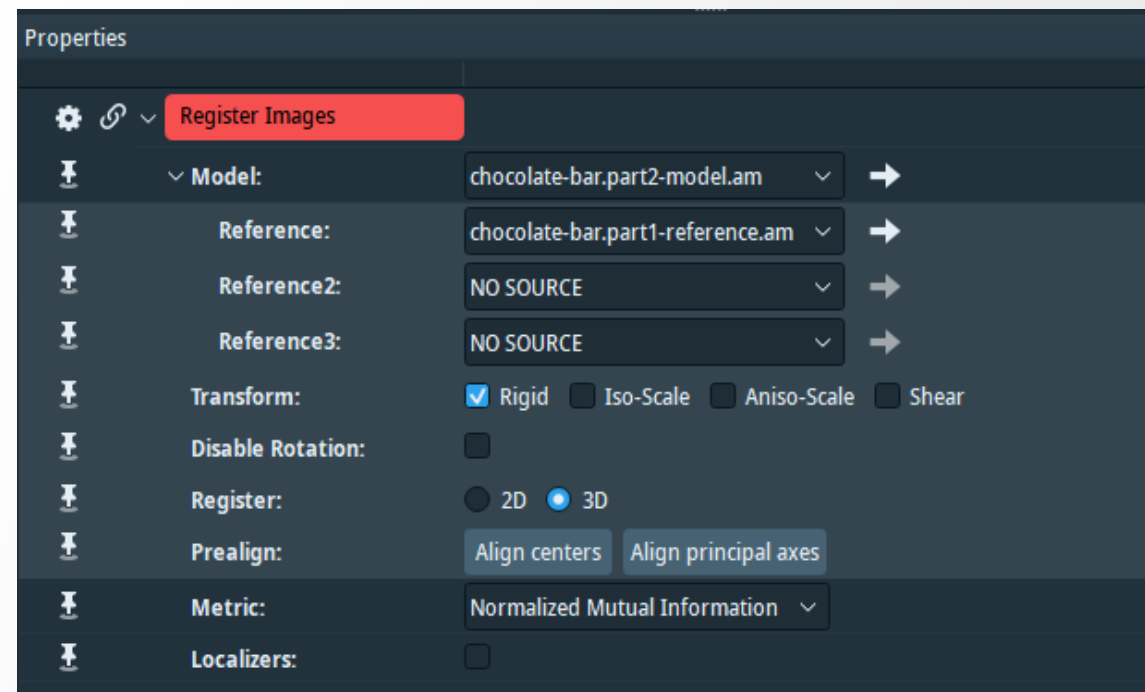
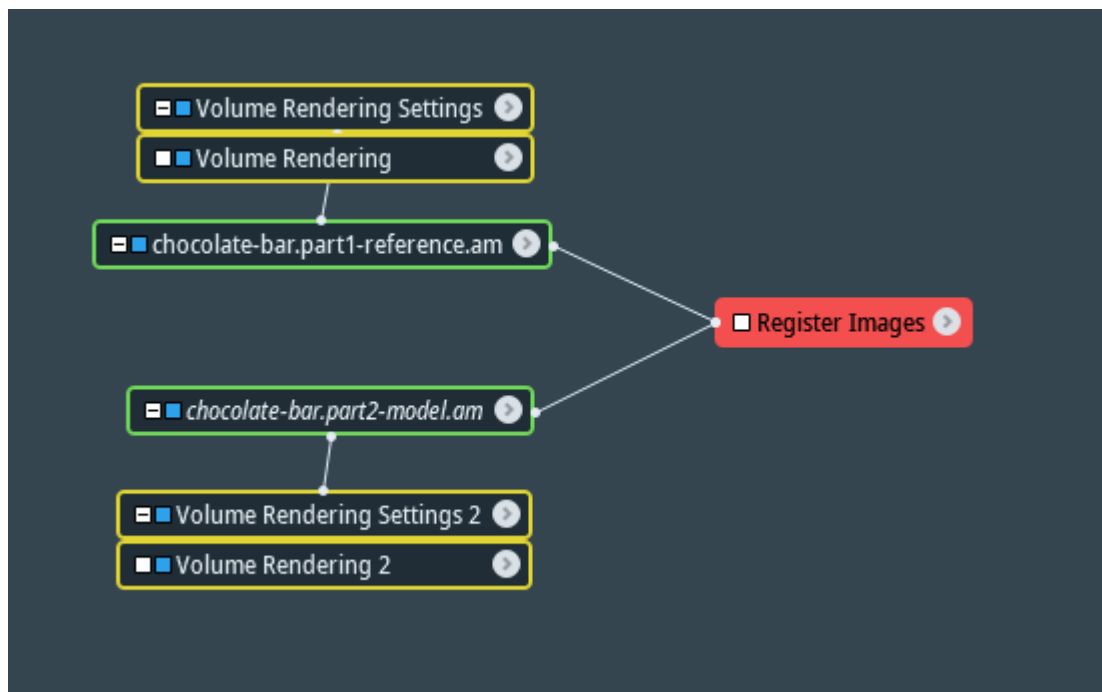
Data registration: Transform Editor module

Move the handle box and bring `chocolate-bar.part2-model.am` (in yellow) to overlap with `chocolate-bar.part1-reference.am` (in green) as much as possible.



Data registration: Register Images module

Attach **Register Images** to **chocolate-bar.part2-model.am** and set the reference to **chocolate-bar.part1-reference.am**.



- **Transform:** Rigid
- **Register:** 3D
- **Prealign:** Align centers & Align principal axes
- **Metric:** Normalized Mutual Information

Data registration: Resample Transformed Image module

Attach **Resample Transformed Image** to **chocolate-bar.part2-model.am** to apply the transformation (otherwise the transformation will be available for visualization only).

The screenshot displays a software interface with a workflow diagram on the left and a 3D visualization of a chocolate bar model on the right. The workflow diagram shows a sequence of modules: 'Volume Rendering Settings' and 'Volume Rendering' are connected to 'chocolate-bar.part1-reference.am'. 'chocolate-bar.part1-reference.am' and 'chocolate-bar.part2-model.am' are connected to 'Register Images'. 'chocolate-bar.part2-model.am' and 'chocolate-bar.part2-model.transformed*' are connected to 'Resample Transformed Image'. 'chocolate-bar.part2-model.transformed*' is also connected to 'Volume Rendering Settings 2' and 'Volume Rendering 2'. The 'Resample Transformed Image' module is highlighted in red. Below the workflow diagram is a 'Properties' panel for the 'Resample Transformed Image' module, showing the following settings:

- Data: chocolate-bar.part2-model.am
- Interpolation: Standard
- Mode: extended
- Preserve: Voxel Size
- Padding Value: 0

The 3D visualization on the right shows a chocolate bar model with a green and yellow color scheme, representing the registration of the two parts.

Image fusion & stitching

Attach **Merge** module to **chocolate-bar.part2-model.transformed** and set **chocolate-bar.part1-reference.am** as a reference. Merge using standard interpolation with blend option.

Properties

Merge

Data: chocolate-bar.part2-model.transformed →

Lattice1: chocolate-bar.part1-reference.am →

Lattice2: NO SOURCE →

Lattice3: NO SOURCE →

Lattice4: NO SOURCE →

Lattice5: NO SOURCE →

Lattice6: NO SOURCE →

Lattice7: NO SOURCE →

Lattice8: NO SOURCE →

Lattice9: NO SOURCE →

Lattice10: NO SOURCE →

Interpolation: Standard ▾

Padding Value: 0

Options: blend use existing result

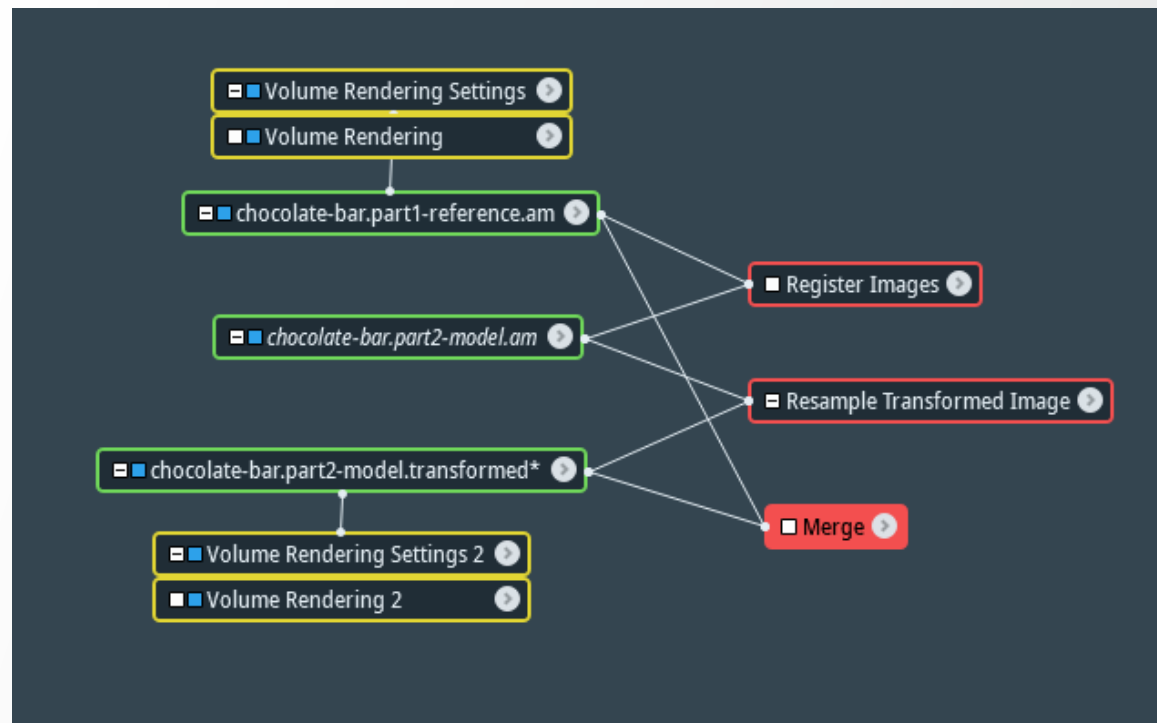
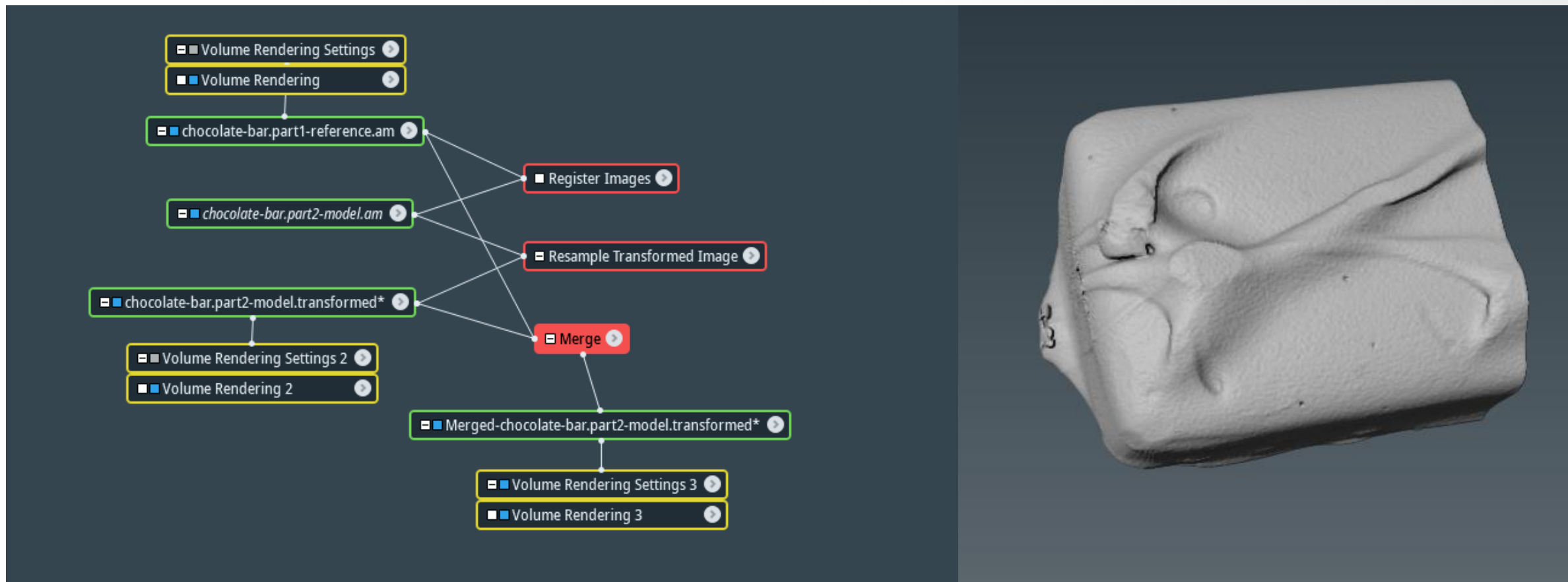


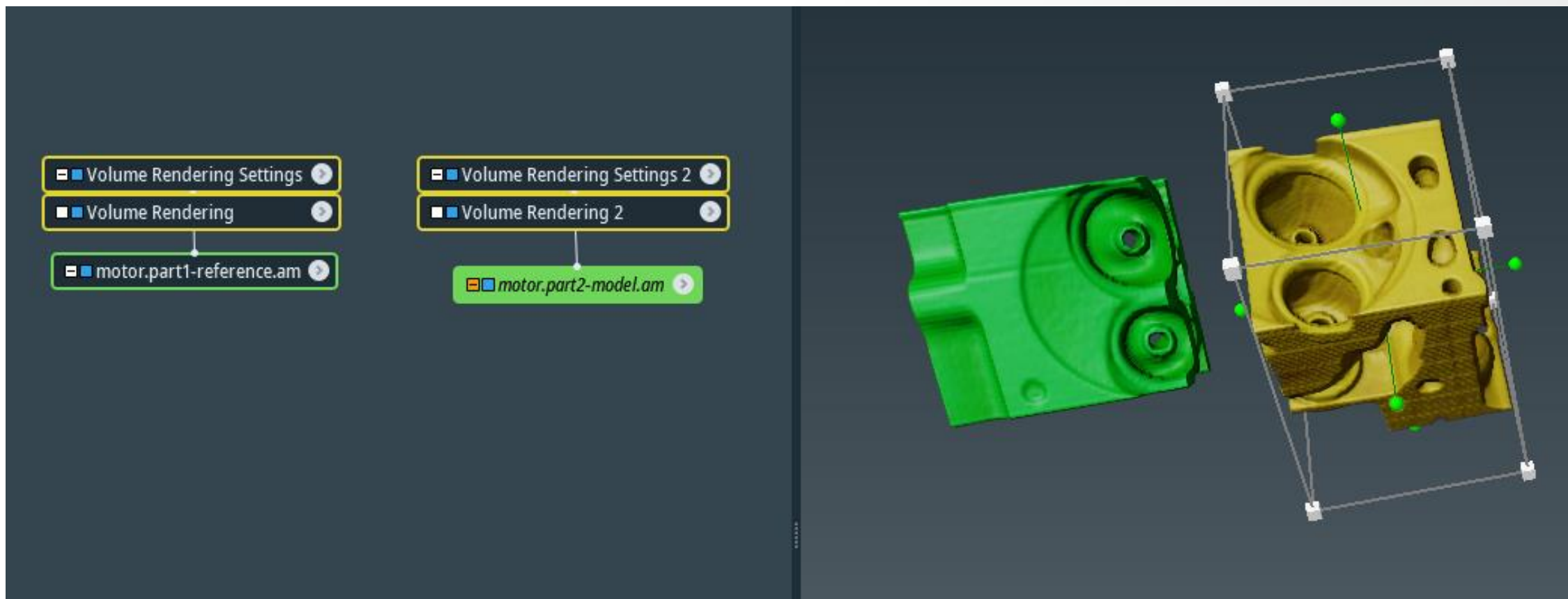
Image fusion & stitching



Data registration: exercise

Register and merge parts of motor data

Register and merge the motor parts (...data/registration/motor.part1-reference.am & motor.part2-model.am)

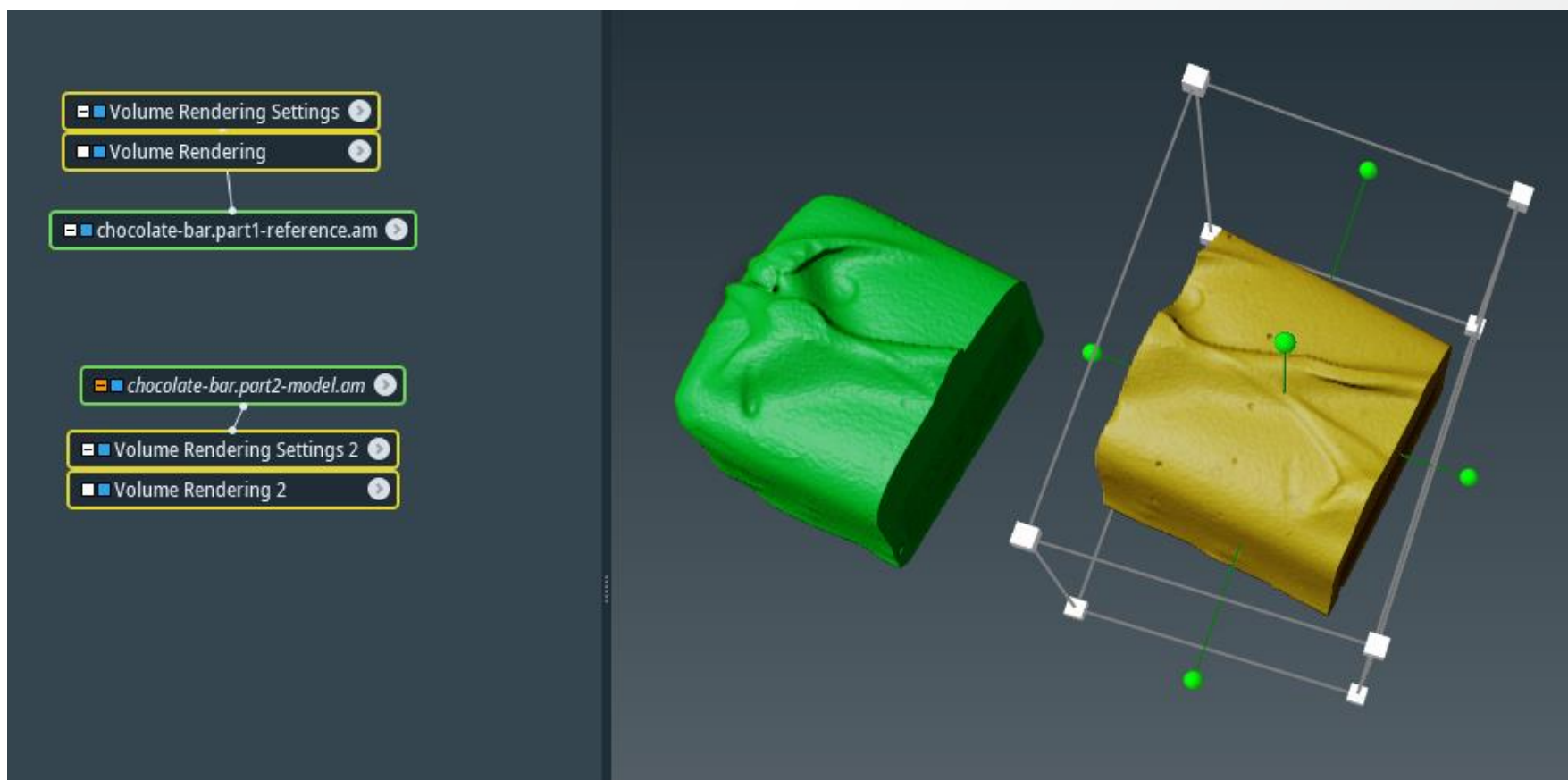


Data registration: exercise

Register and merge parts of chocolate bar data

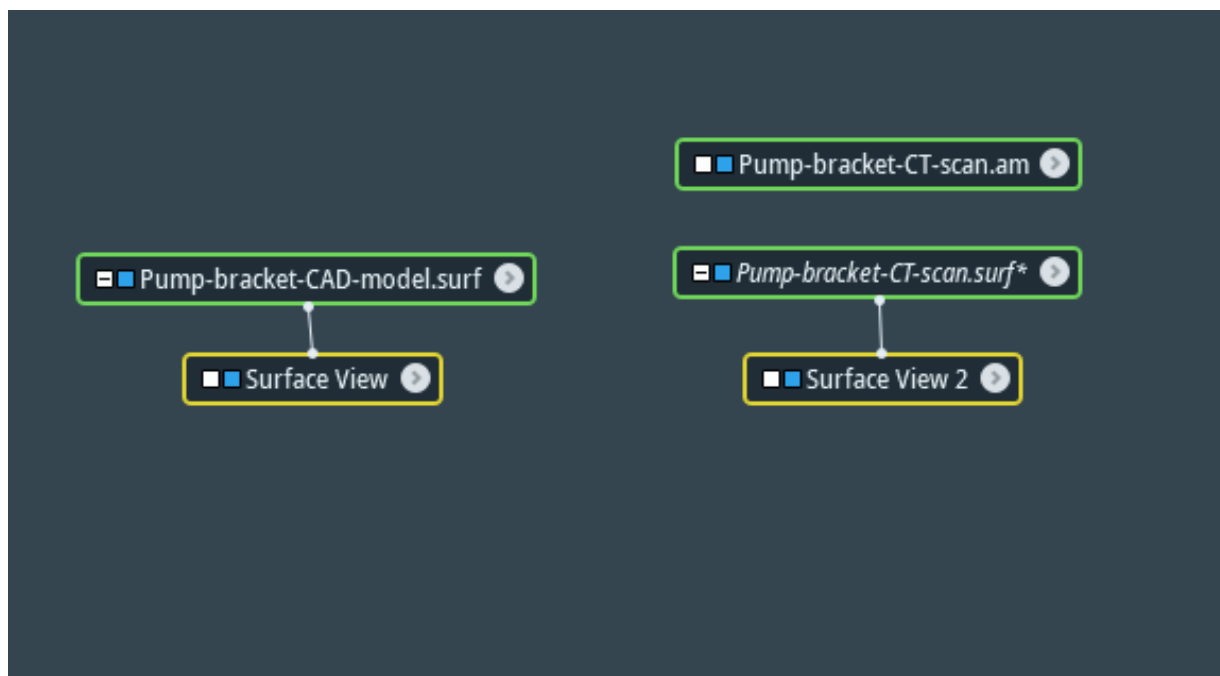
Register and merge the chocolate bar parts

(...data/registration/chocolate-bar.part1-reference.am chocolate-bar.part2-model.am)



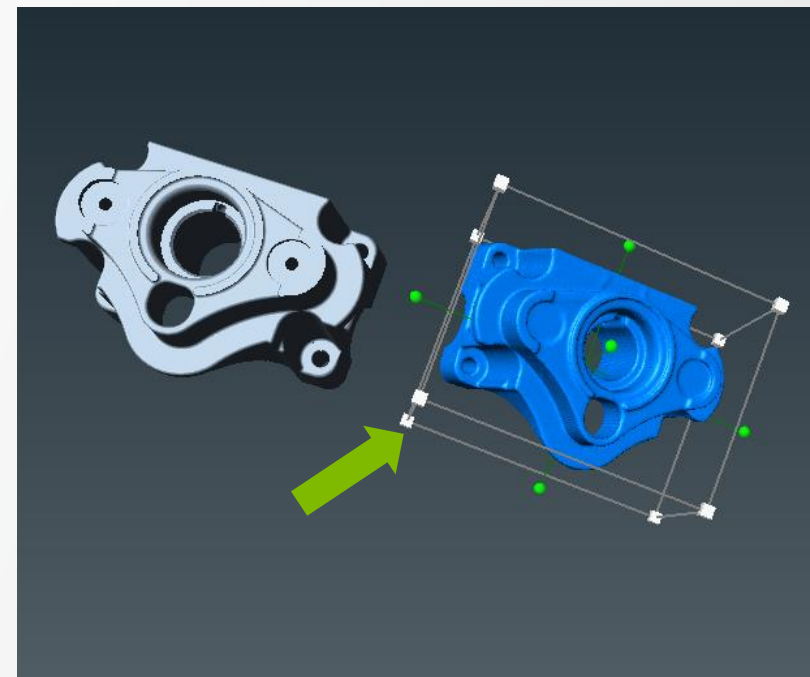
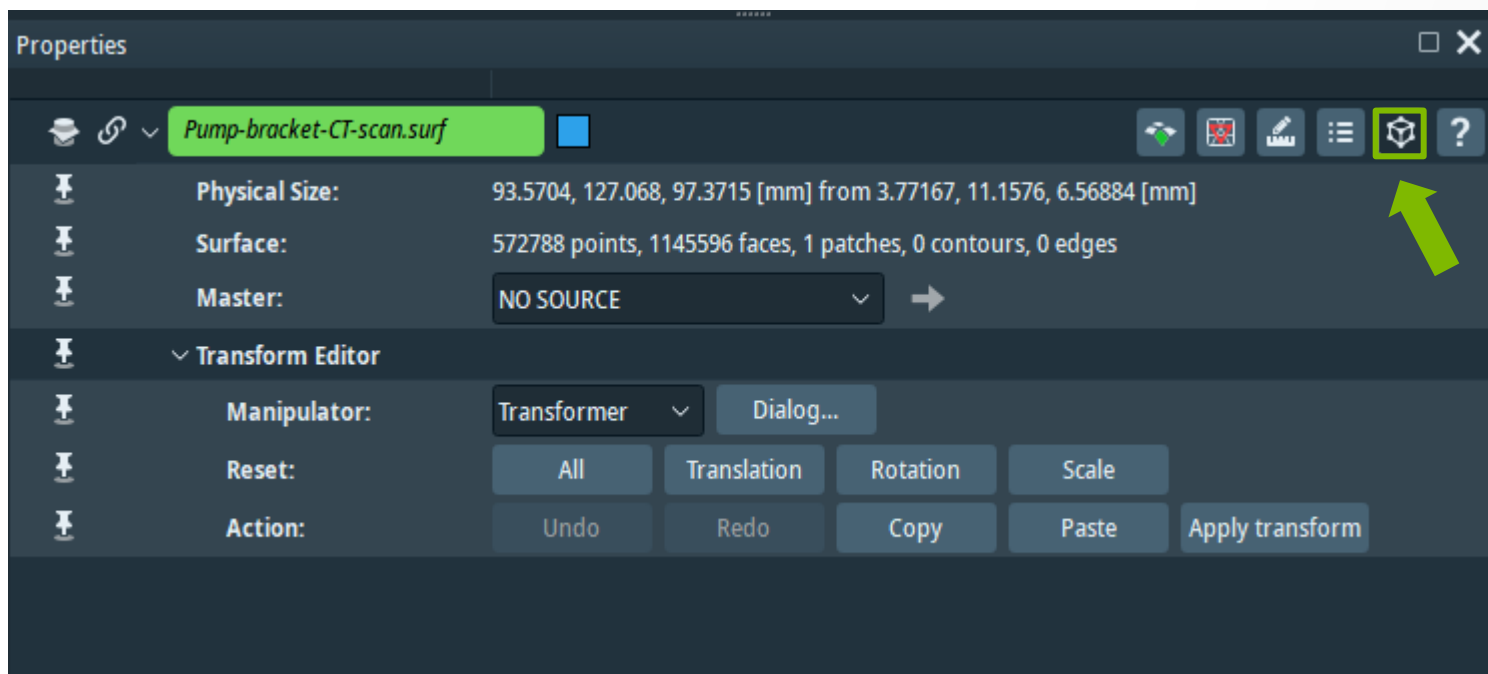
Nominal-Actual comparison

Open **Pump-bracket-CAD-model.surf** and **Pump-bracket-CT-scan.am** (...data/pump-bracket) then generate a binary image (thresholding) and then generate surface from **Pump-bracket-CT-scan.am** and attach **Surface View** to both surfaces.



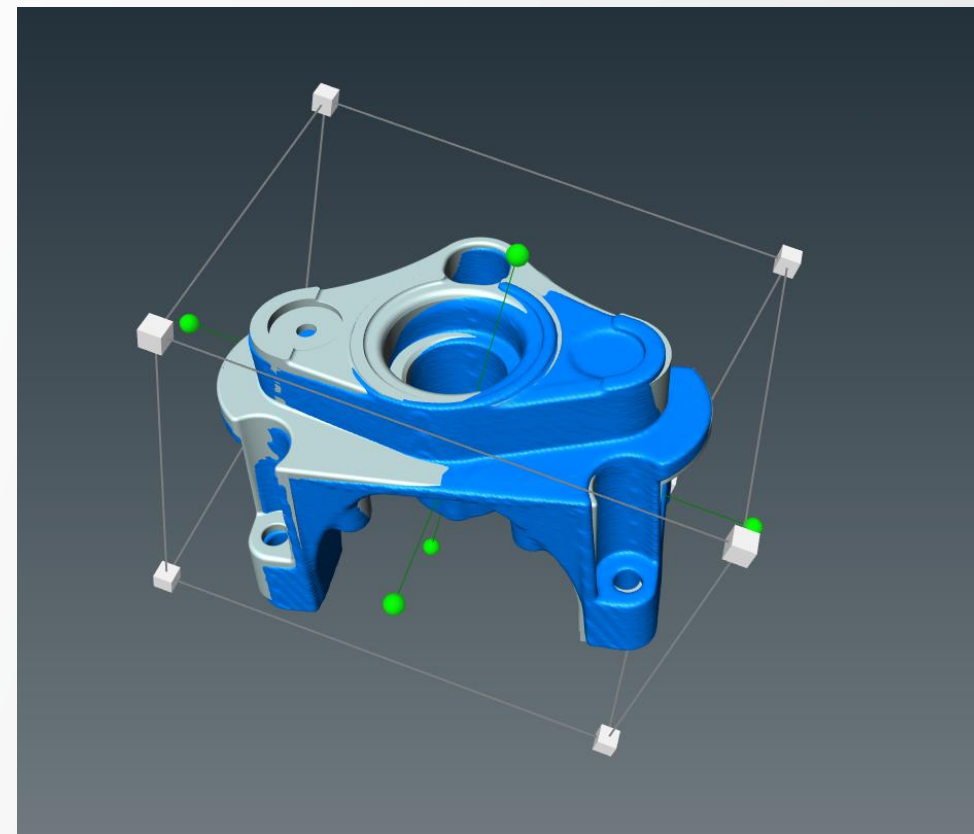
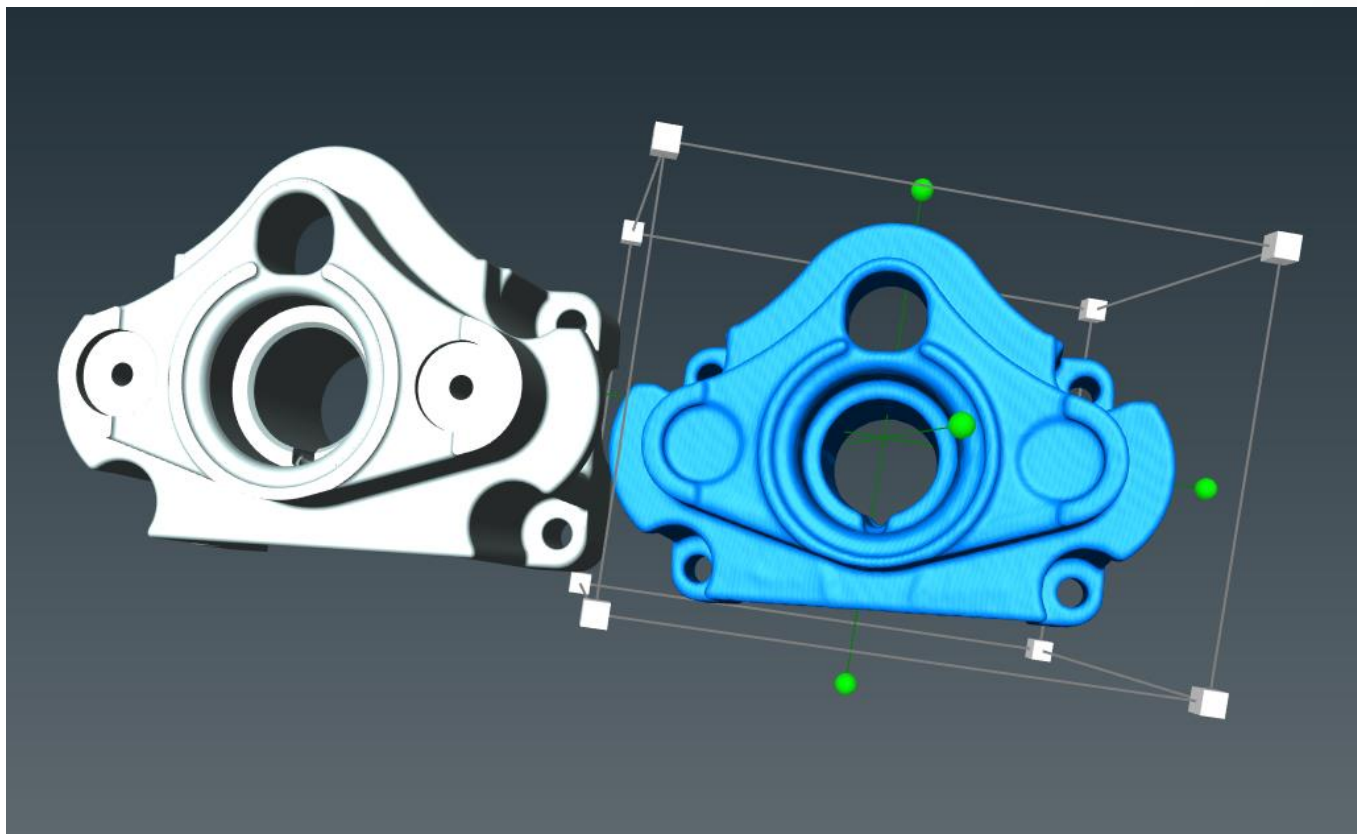
Nominal-Actual comparison example

In the properties window of *Pump-bracket-CT-scan.surf*, activate **Transform Editor**, the transform box will appear.



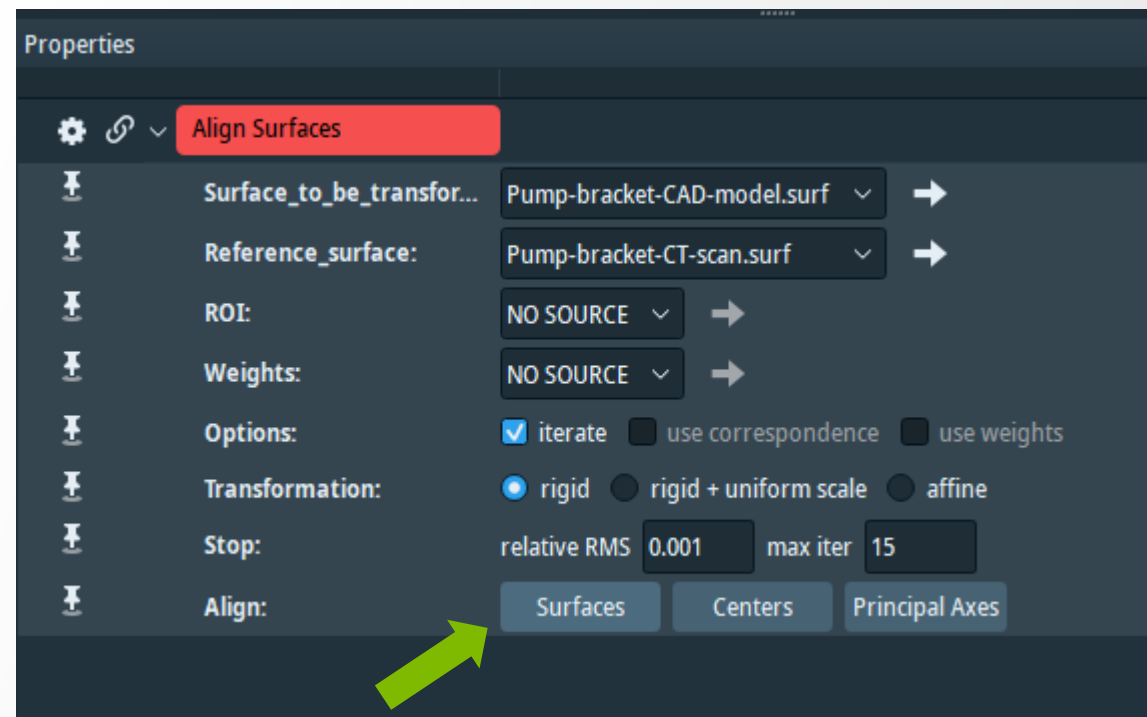
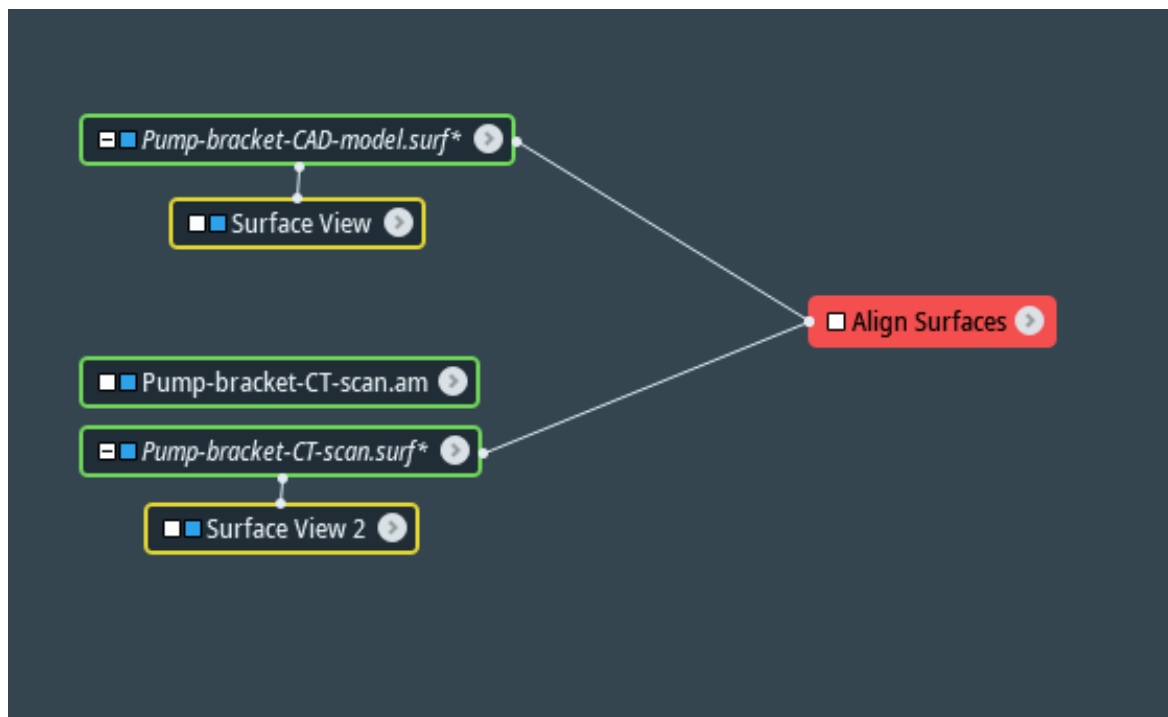
Nominal-Actual comparison example

Move the handle box and bring *Pump-bracket-CT-scan.surf* to overlap with *Pump-bracket-CAD-model.surf* as much as possible.



Nominal-Actual comparison example

Attach *Align Surfaces* to *Pump-bracket-CAD-model.surf* and set the reference to *Pump-bracket-CT-scan.surf*.



- Options: iterate
- Transformation: rigid
- Stop: relative RMS = 0.001, max iter = 15
- Align: Surfaces

Nominal-Actual comparison example

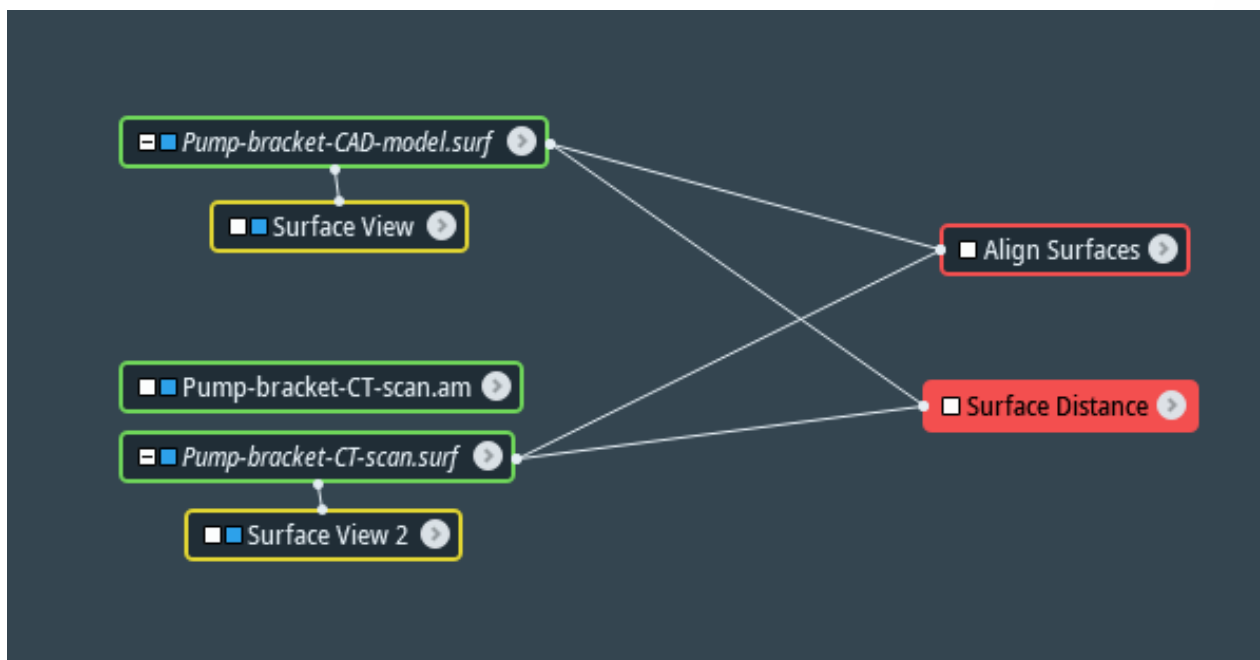
The screenshot displays the 'Align Surfaces' tool configuration in a software interface. The tool is used to compare a CAD model (nominal) with a CT scan (actual) of a pump bracket. The configuration is as follows:

- Surface to be transformed:** Pump-bracket-CAD-model.surf
- Reference surface:** Pump-bracket-CT-scan.surf
- ROI:** NO SOURCE
- Weights:** NO SOURCE
- Options:** iterate, use correspondence, use weights
- Transformation:** rigid, rigid + uniform scale, affine
- Stop:** relative RMS 0.001, max iter 15
- Align:** Surfaces, Centers, Principal Axes

The 3D model on the right shows the pump bracket with the CAD model overlaid on the CT scan data, illustrating the alignment process.

Nominal-Actual comparison: e.g. Surface Distance

Attached **Surface Distance** module to **Pump-bracket-CAD-model.surf** (surface 1) and **Pump-bracket-CT-scan.surf** (surface 2).



Properties

Surface Distance

Surface 1: Pump-bracket-CAD-model.surf →

Surface 2: Pump-bracket-CT-scan.surf →

ROI: NO SOURCE →

Direction: Surface 1->2

Output: Vectors Distance TriIdx

Consider: patches contours isolated points

Maximal Distance [mm]: 1

Above Threshold: 0.5

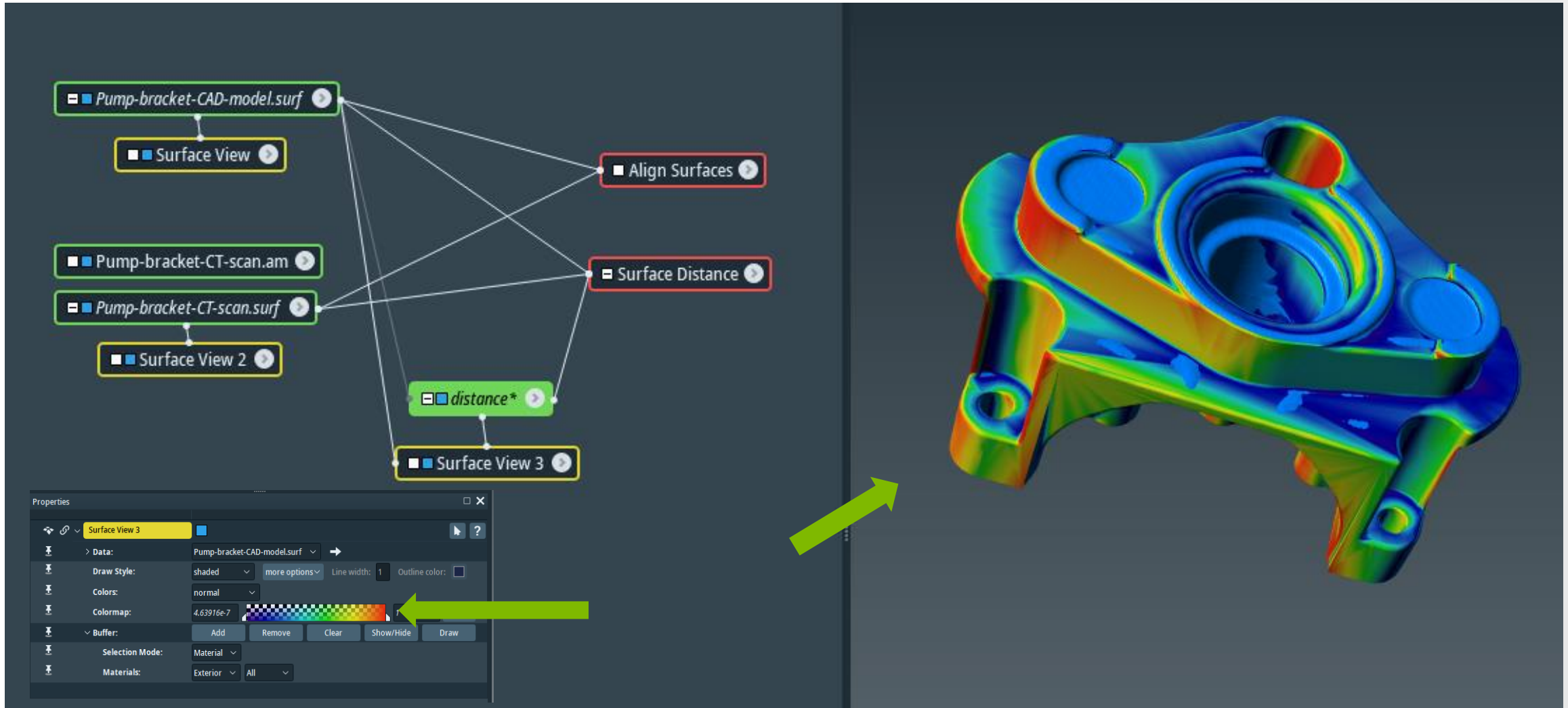
Results

Stats 1: [mm]:	mean 0.451269 dev 0.293069 rms 0.538082 max 1
Stats 2: [mm]:	median 0.422175 aboveThresh 42.4328 % corrRms 0

- **Direction:** Surface 1->2
- **Output:** Distance
- **Maximal Distance:** 1
- **Above Threshold:** 0.5

Nominal-Actual comparison: e.g. Surface Distance

Visualize distance with Surface View, set color map to Physics

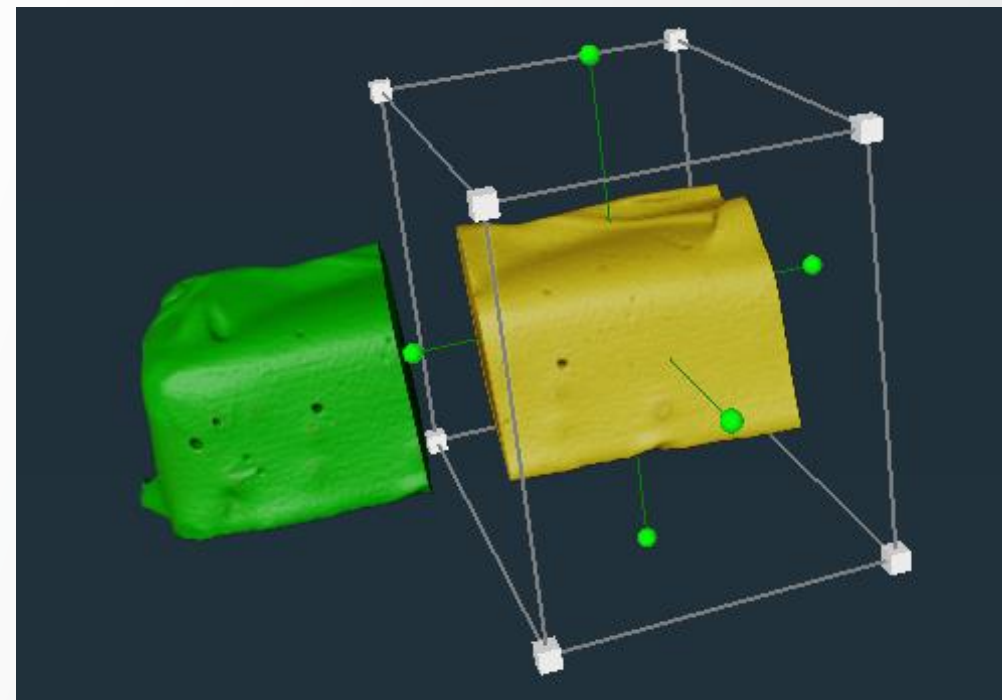


Landmark-based registration: introduction

- Landmarks are useful for registration and alignment of multiple 3D images.
- It allows you to store multiple sets of corresponding marker positions.
- The data type can also be used to represent a simple list of 3D points.

Landmark-based registration: example

Open `chocolate-bar.part1-reference.am` and `chocolate-bar.part2-model.am` (data -> registration) then attach **Volume Rendering** to each dataset.

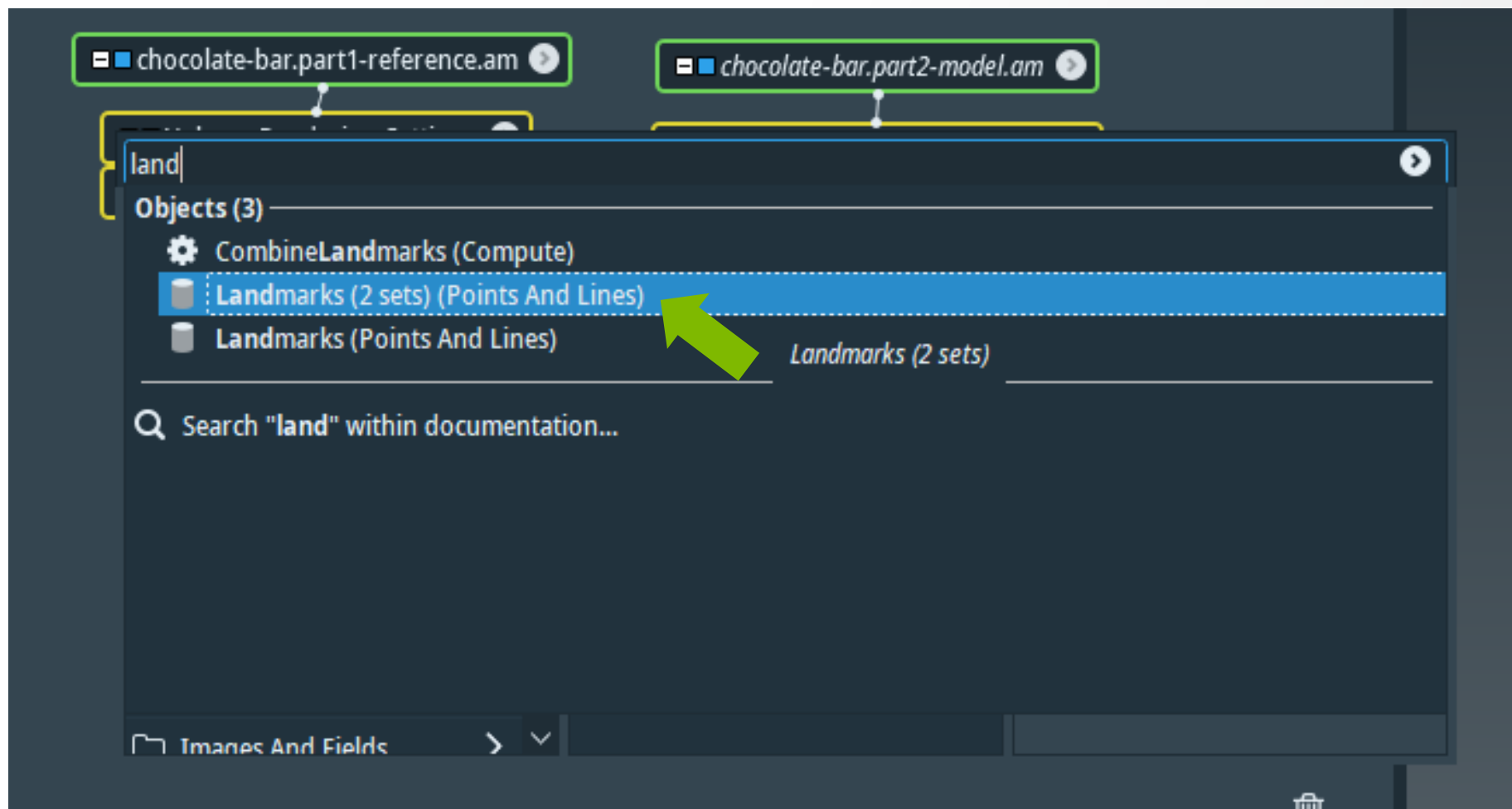


In the properties window of `chocolate-bar.part2-model.am`, activate **Transform Editor**, the transform box will appear. Move the handle box and bring `chocolate-bar.part2-model.am` (in yellow) to align with `chocolate-bar.part1-reference.am` (in green) as much as possible.

Once satisfied apply Resample transform Image to save the transformed dataset.

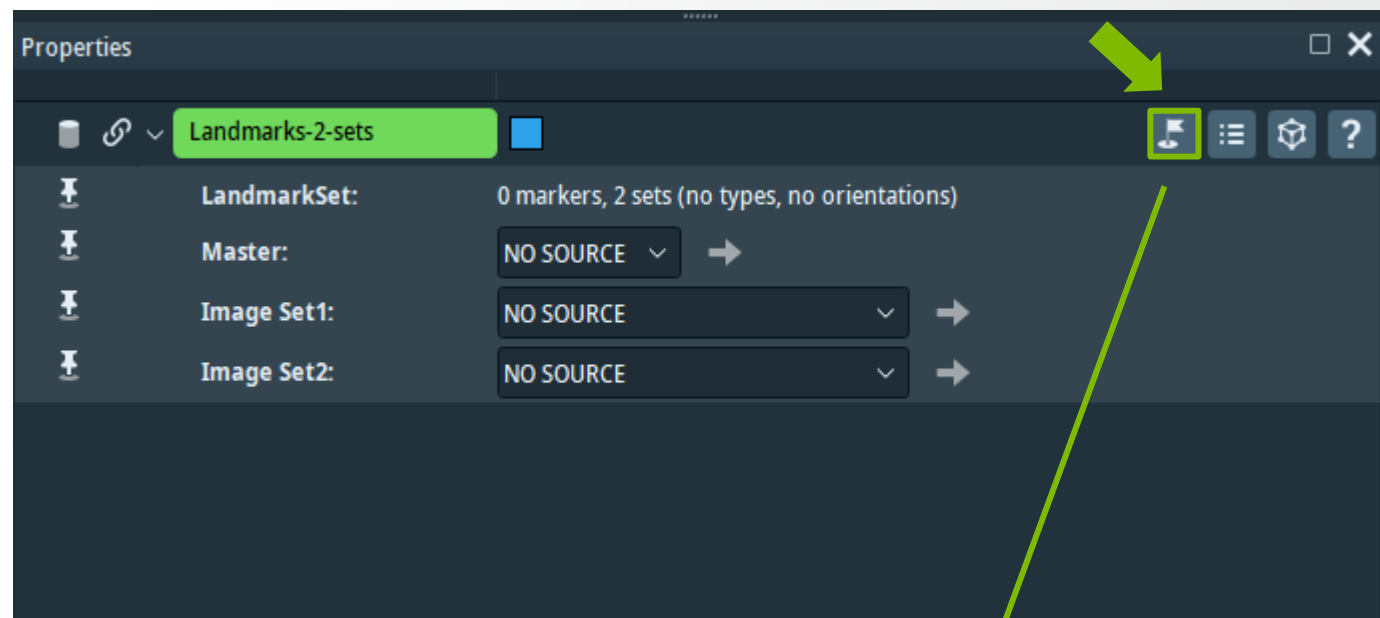
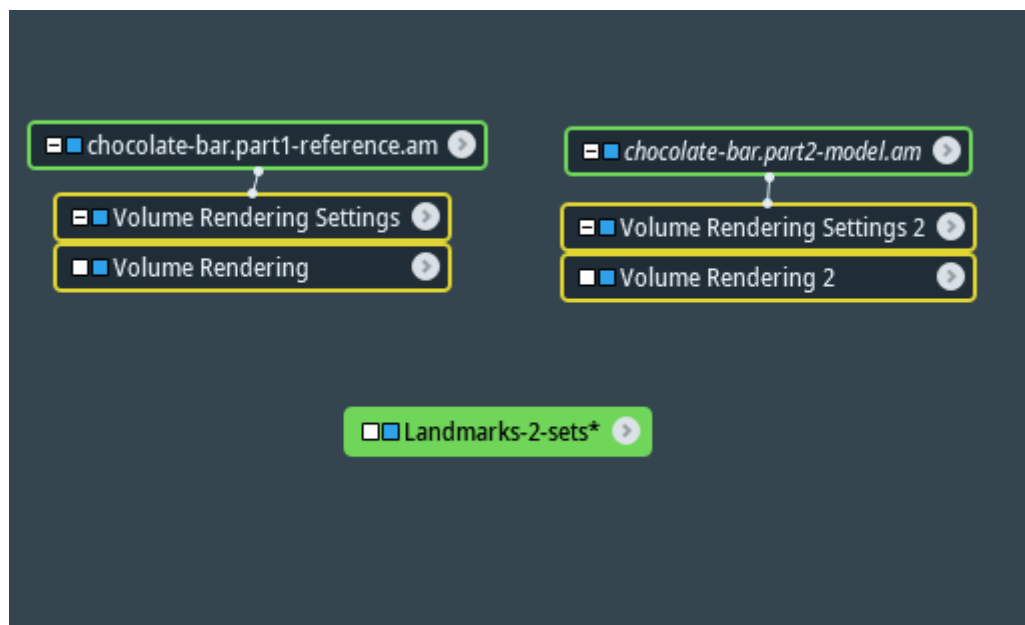
Landmark-based registration: example

In Project View, right-click and “**Create Object**”, select **Landmarks (2 sets) (Points And Lines)**.



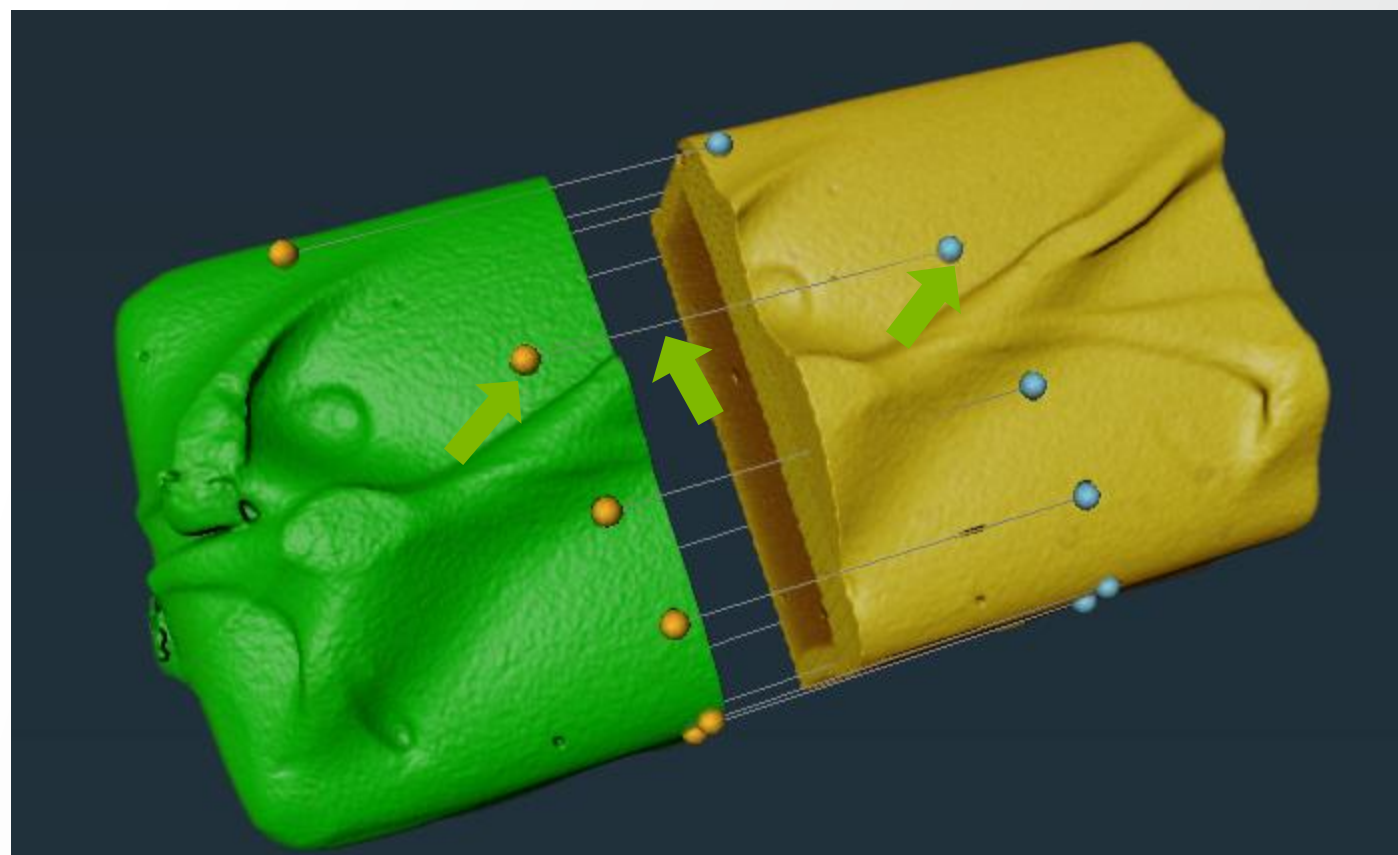
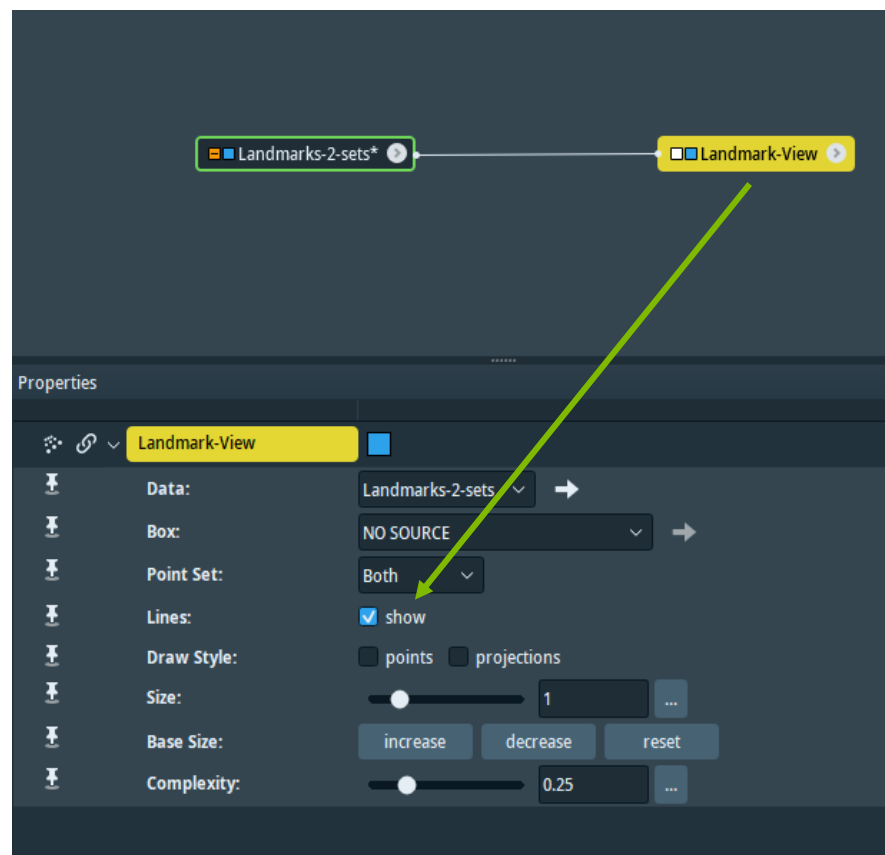
Landmark-based registration: example

Activate **Landmark Editor** in the properties port of **Landmarks-2-sets**, **Landmark View** will appear.



Landmark-based registration: example

In **Landmark-View** select to show lines. Then go back to **Landmarks-2-sets** to start adding points by click on **chocolate-bar.part1-reference.am** (yellow dots) and connect to **chocolate-bar.part2-model.am** (light-blue dots). Line sets between the two volumes will be shown. Rotate the volumes and add more points and lines to connect common landmarks between the two volumes. Do not make crossing lines.

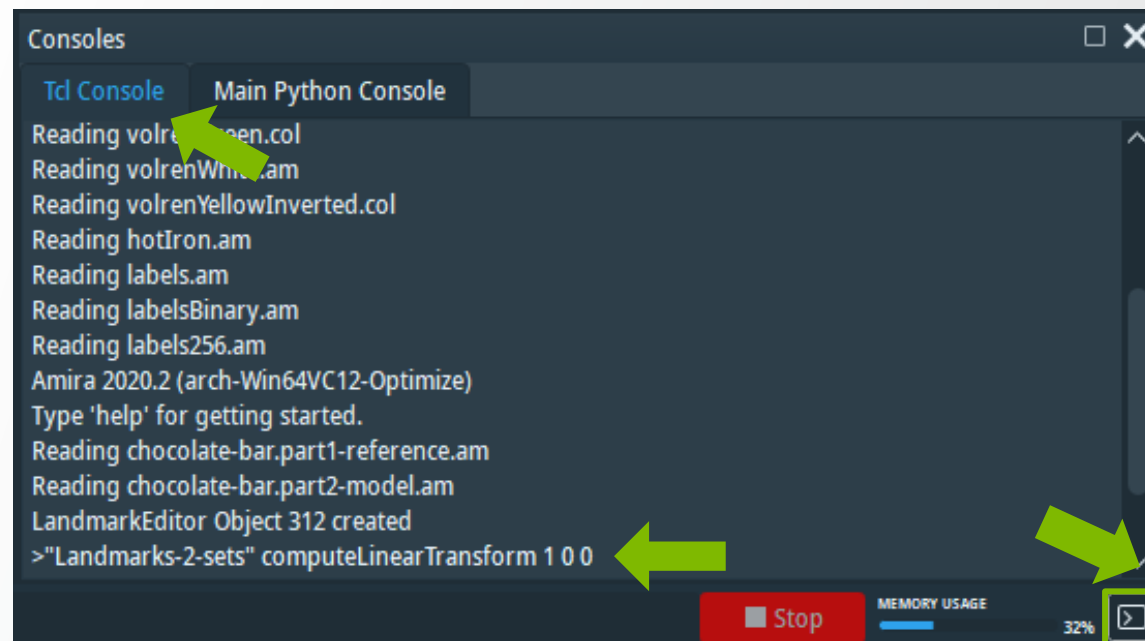
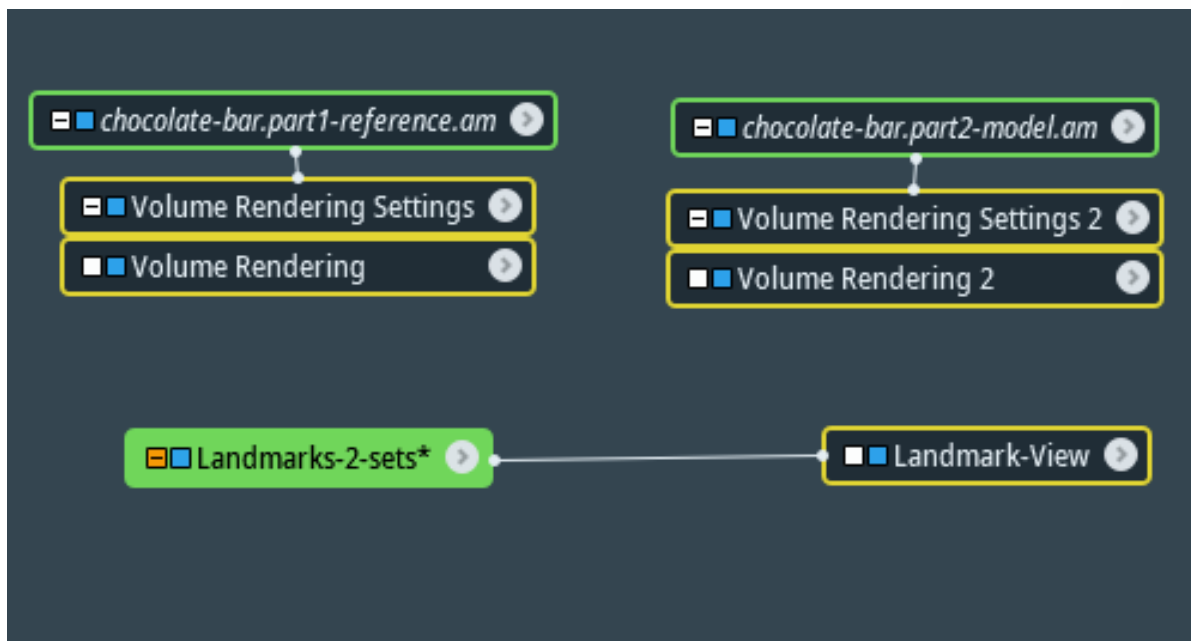


Landmark-based registration: example

Open **Tcl** console, then come back to “Project View” and click on “Landmarks-2-sets”. Next go back to **Tcl Console** and then press “Tab” to activate- > “Landmarks-2-sets” and input “computeLinearTransform 1 0 0”:

- “Landmarks-2-sets” computeLinearTransform 1 0 0


Press enter.



Landmark-based registration: example

Go back to **Project View** and click on **chocolate-bar.part2-model_transformed.am**. Then go back to **Tcl Console** and then press “Tab” to activate -> “chocolate-bar.part2-model-transformed.am” and input setTransform and paste the values from previous step:

- “chocolate-bar.part1-reference.am” setTransform 0.999631 -0.0174218 -0.020835 0 0.0176621 0.999779 0.0114049 0 0.0206318 -0.0117689 0.999718 0 -0.375237 0.593657 -18.5194 1
- Press enter.



The screenshot shows a Tcl Console window with the following text:

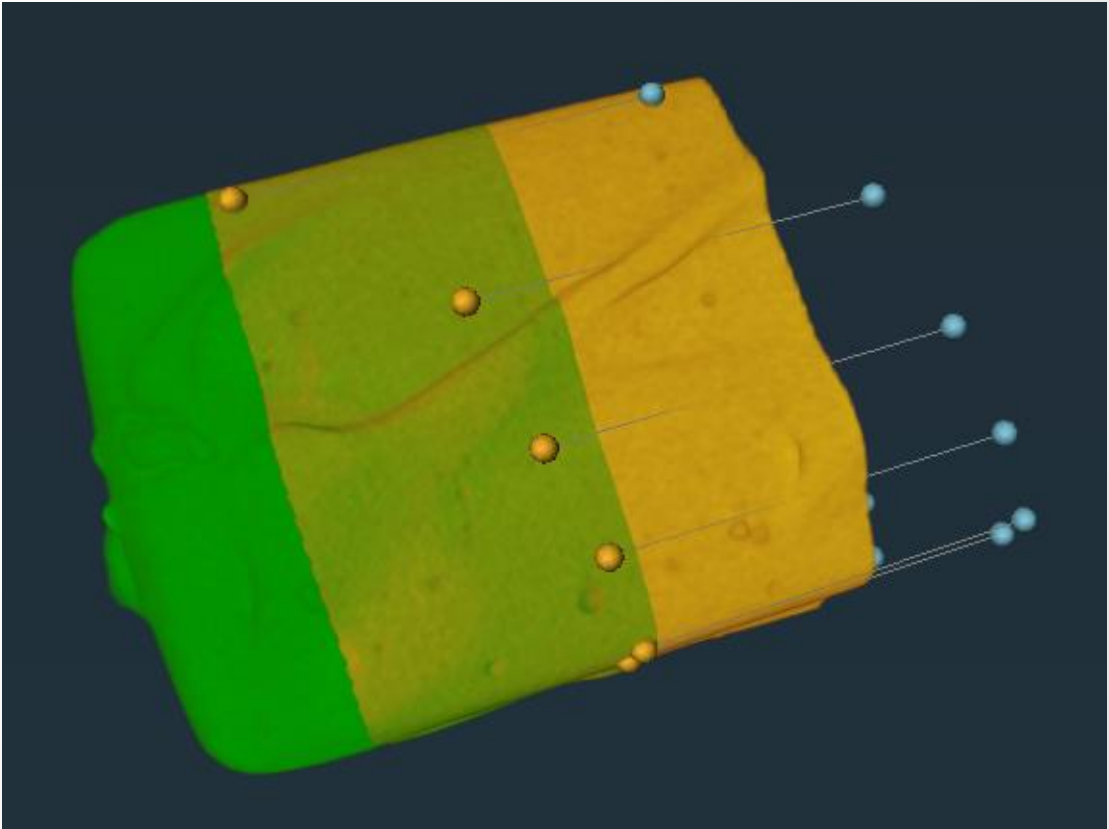
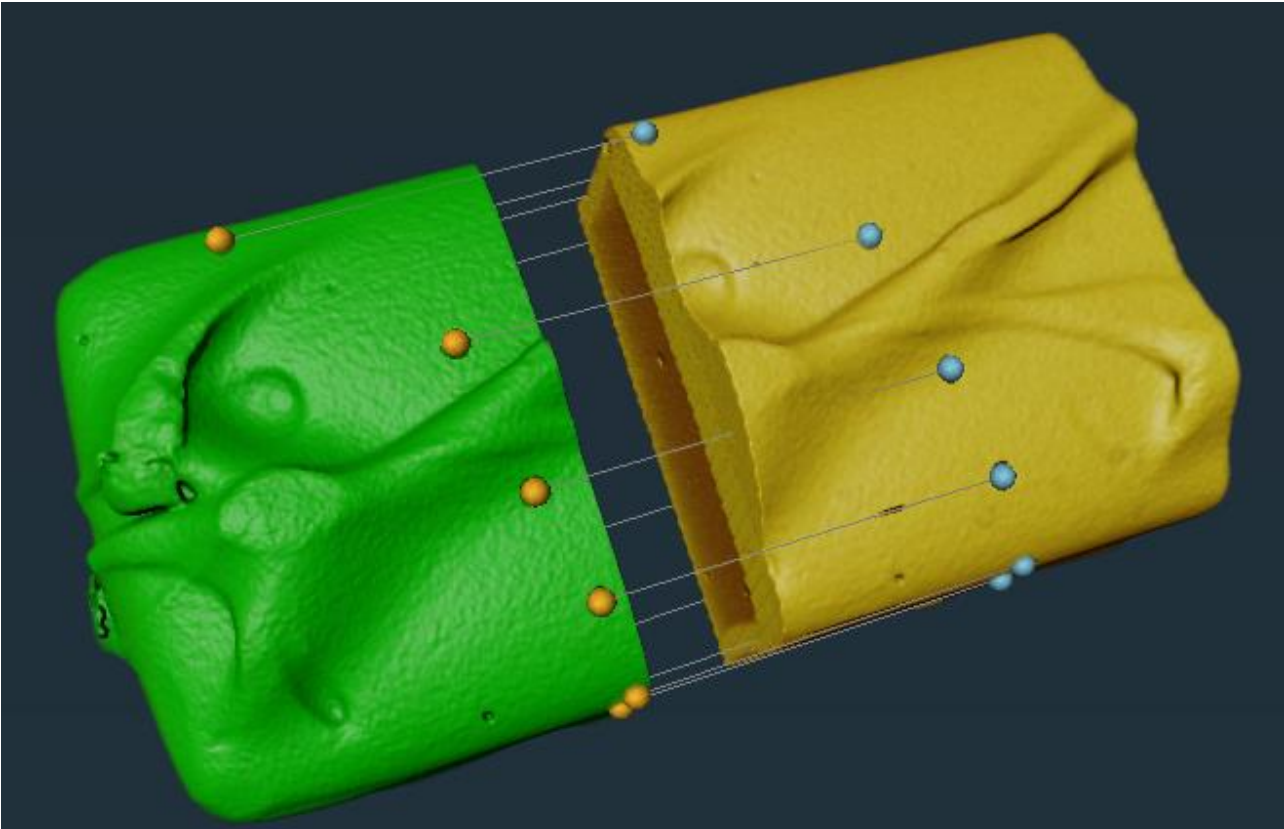
```
Consoles
Tcl Console Main Python Console
Reading labelsBinary.am
Reading labels256.am
Amira 2020.2 (arch-Win64VC12-Optimize)
Type 'help' for getting started.
Reading chocolate-bar.part1-reference.am
Reading chocolate-bar.part2-model.am
LandmarkEditor Object 312 created
>"Landmarks-2-sets" computeLinearTransform 1 0 0
0.999631 -0.0174218 -0.020835 0 0.0176621 0.999779 0.0114049 0 0.0206318 -0.0117689 0.999718 0 -0.375237 0.593657 -18.5194 1
>"chocolate-bar.part2-model.transformed" setTransform 0.999631 -0.0174218 -0.020835 0 0.0176621 0.999779 0.0114049 0 0.0206318 -0.0117689
0.999718 0 -0.375237 0.593657 -18.5194 1
1
>
```

A green arrow points to the end of the second line of the setTransform command.

At the bottom of the console, there is a red "Stop" button, a "MEMORY USAGE" indicator showing 32%, and a play button icon.

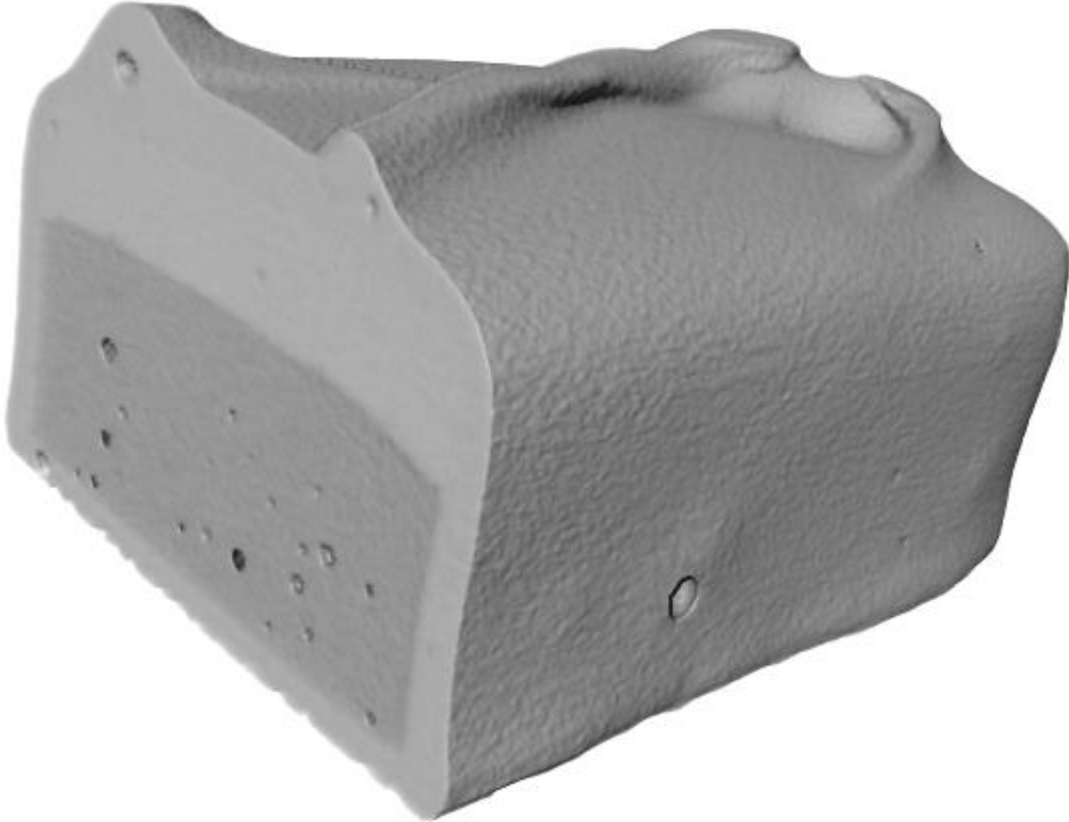
Landmark-based registration: example

Registration result:



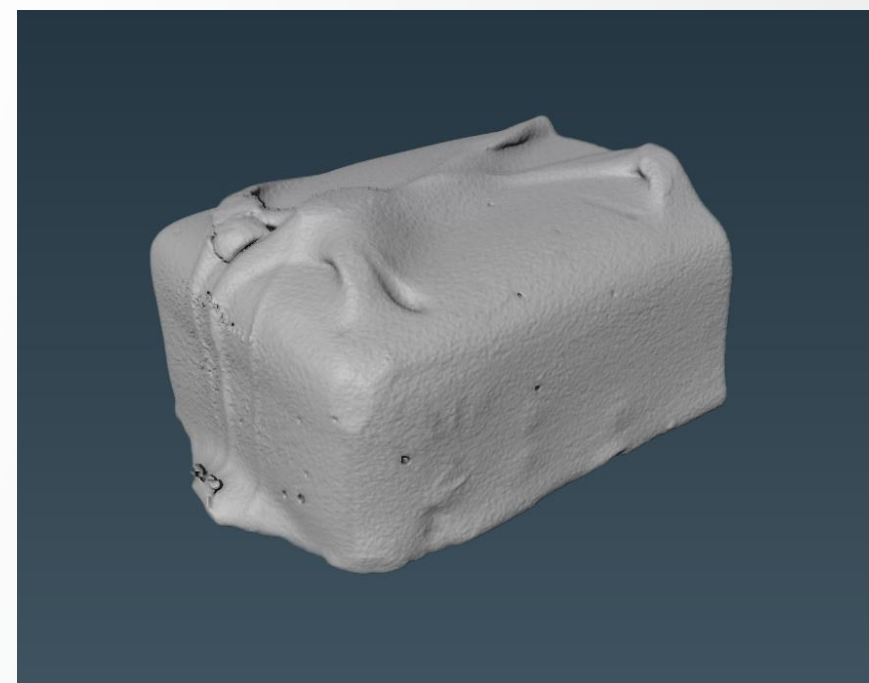
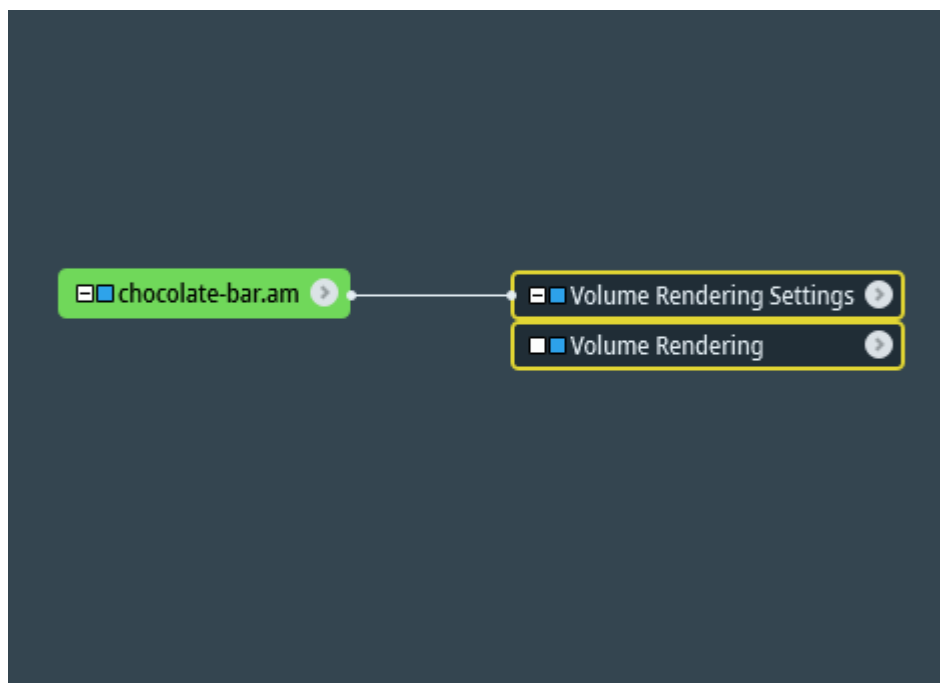
Animation generation

Animation: Camera Path (Rotation)



Animation: Camera Path (rotation)

Open [chocolate-bar.am](#) (data > tutorials) then attach [Volume Rendering](#) to the dataset.

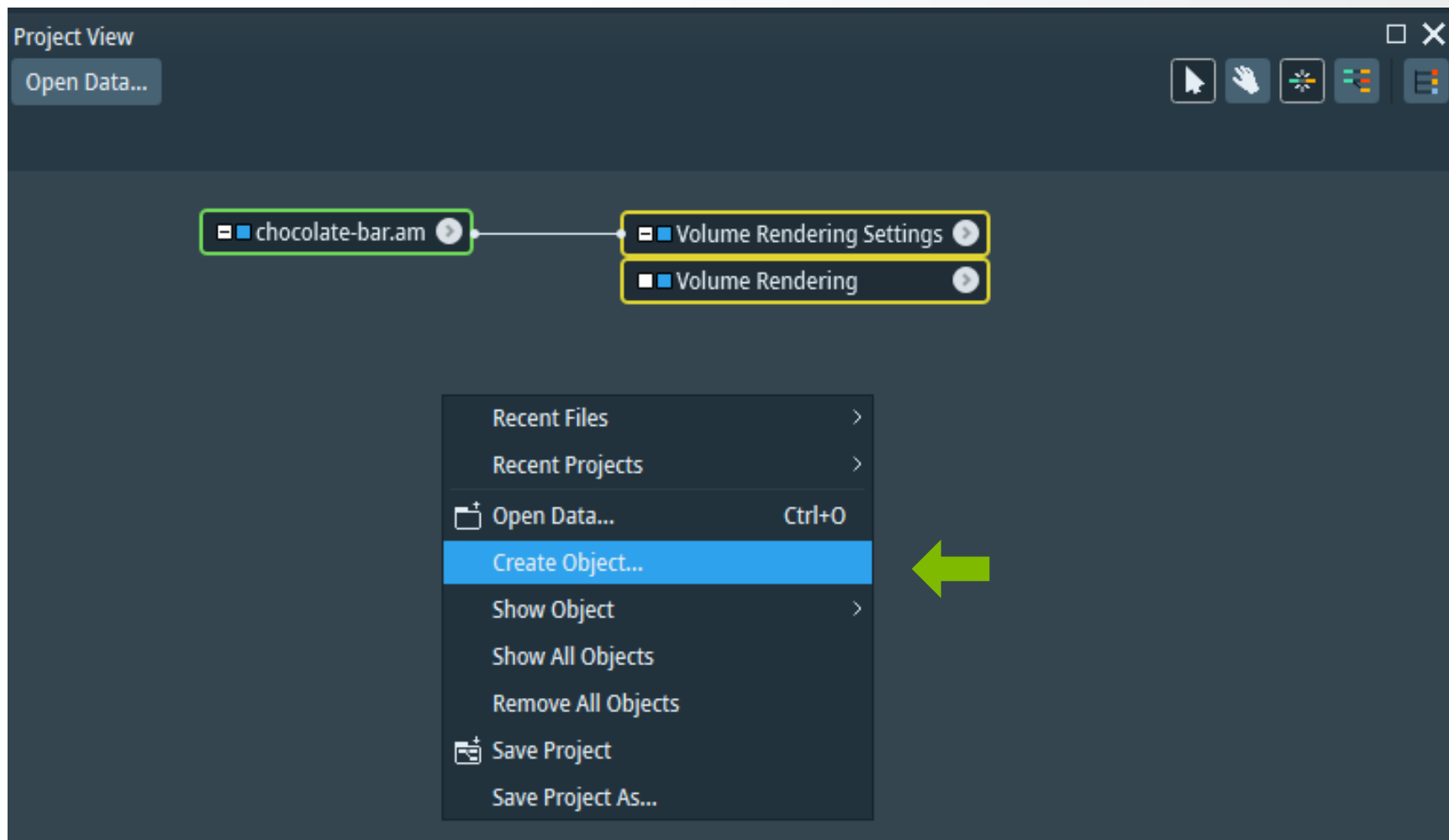


Animation: Camera Path (rotation)

Attach Camera Path

Right-Click anywhere in the project view

- **Create Object**

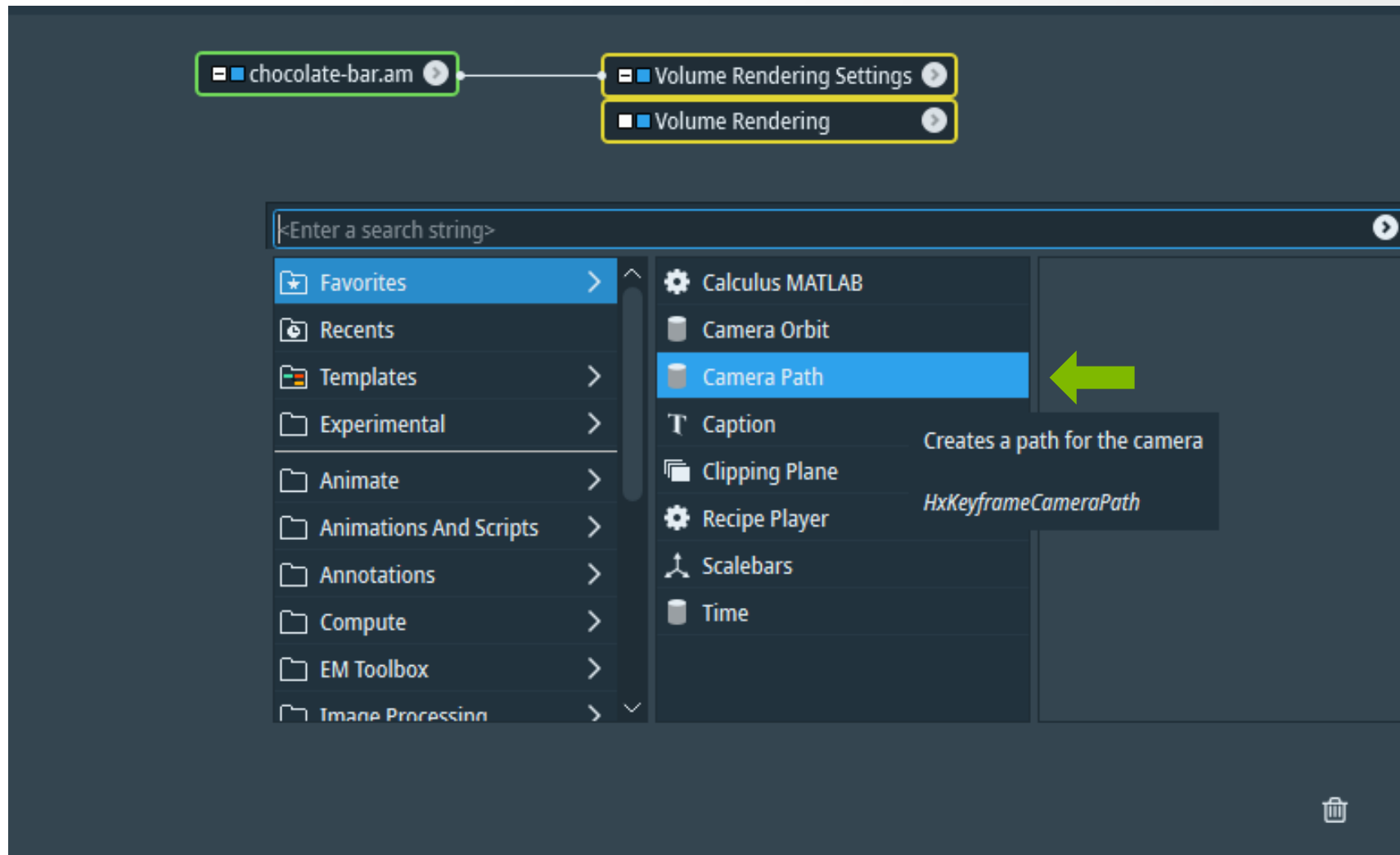


Animation: Camera Path (rotation)

Attach Camera Path

Right-Click anywhere in the project view

- Create Object
- **Camera Path**



Animation: Camera Path (rotation)

Camera Path

Click on the **Camera-Path** module

- **Properties**

The screenshot displays a software interface with a dark background. At the top, there are three modules: 'chocolate-bar.am' (highlighted with a green box), 'Volume Rendering Settings' (highlighted with a yellow box), and 'Volume Rendering' (highlighted with a yellow box). Below these is a 'Camera-Path' module (highlighted with a green box). A green arrow points from the 'Camera-Path' module to the 'Properties' panel below. The 'Properties' panel has a title bar with 'Camera-Path' and a blue square icon. It contains the following settings:

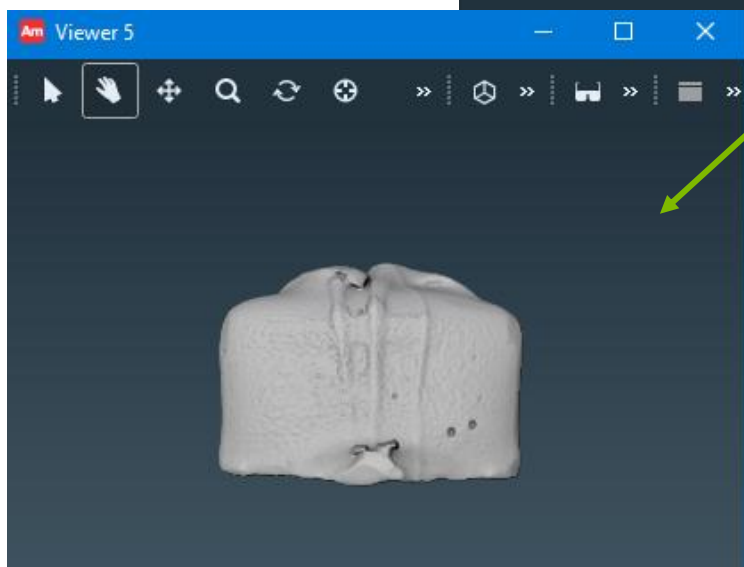
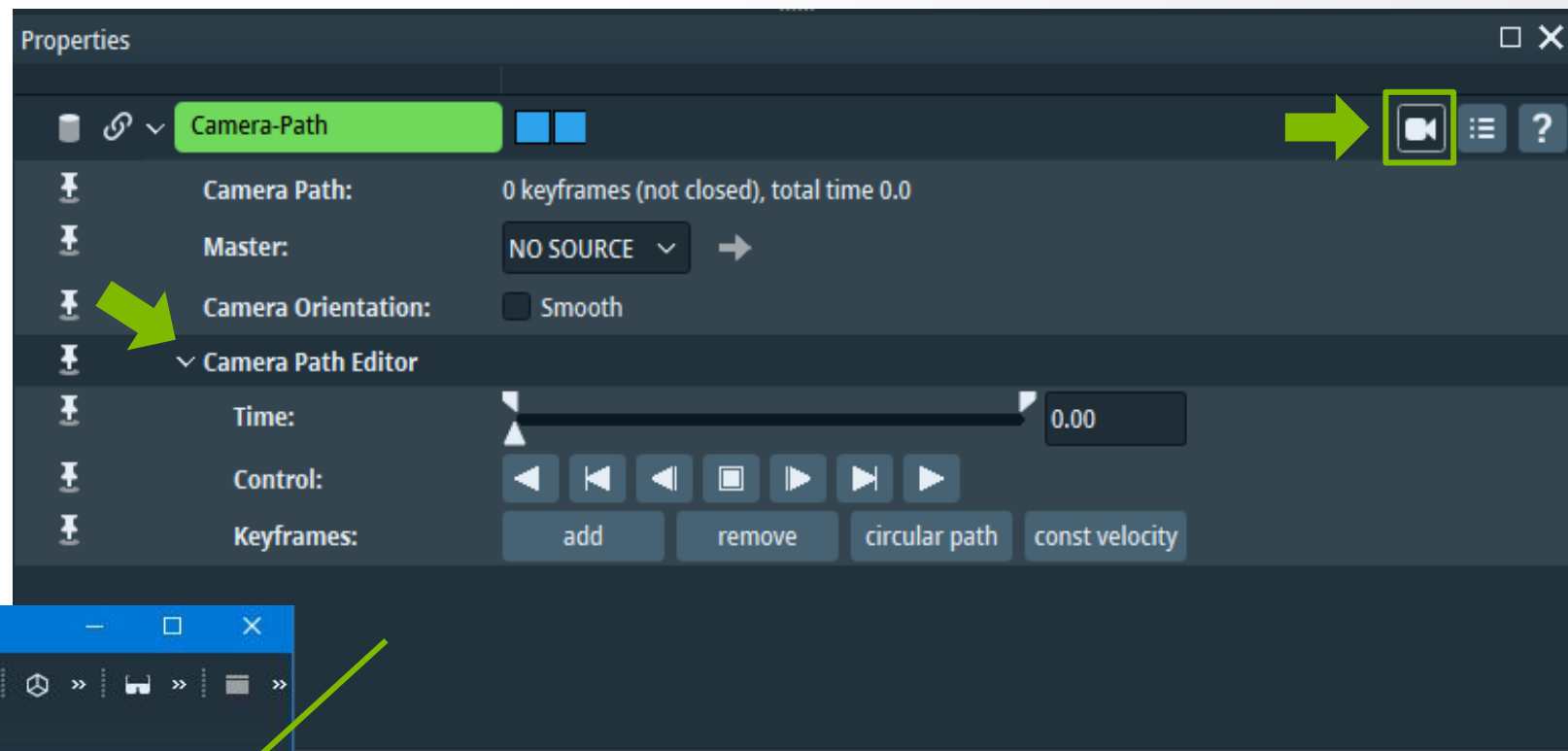
- Camera Path: 0 keyframes (not closed), total time 0.0
- Master: NO SOURCE (dropdown menu)
- Time: Playback controls (stop, play, seek) and a time input field set to 0.
- Camera Orientation: Smooth

Animation: Camera Path (rotation)

Camera Path

Click **Camera Path Editor** icon (top-right) to start adding key frames.

A small camera path view will also appear.



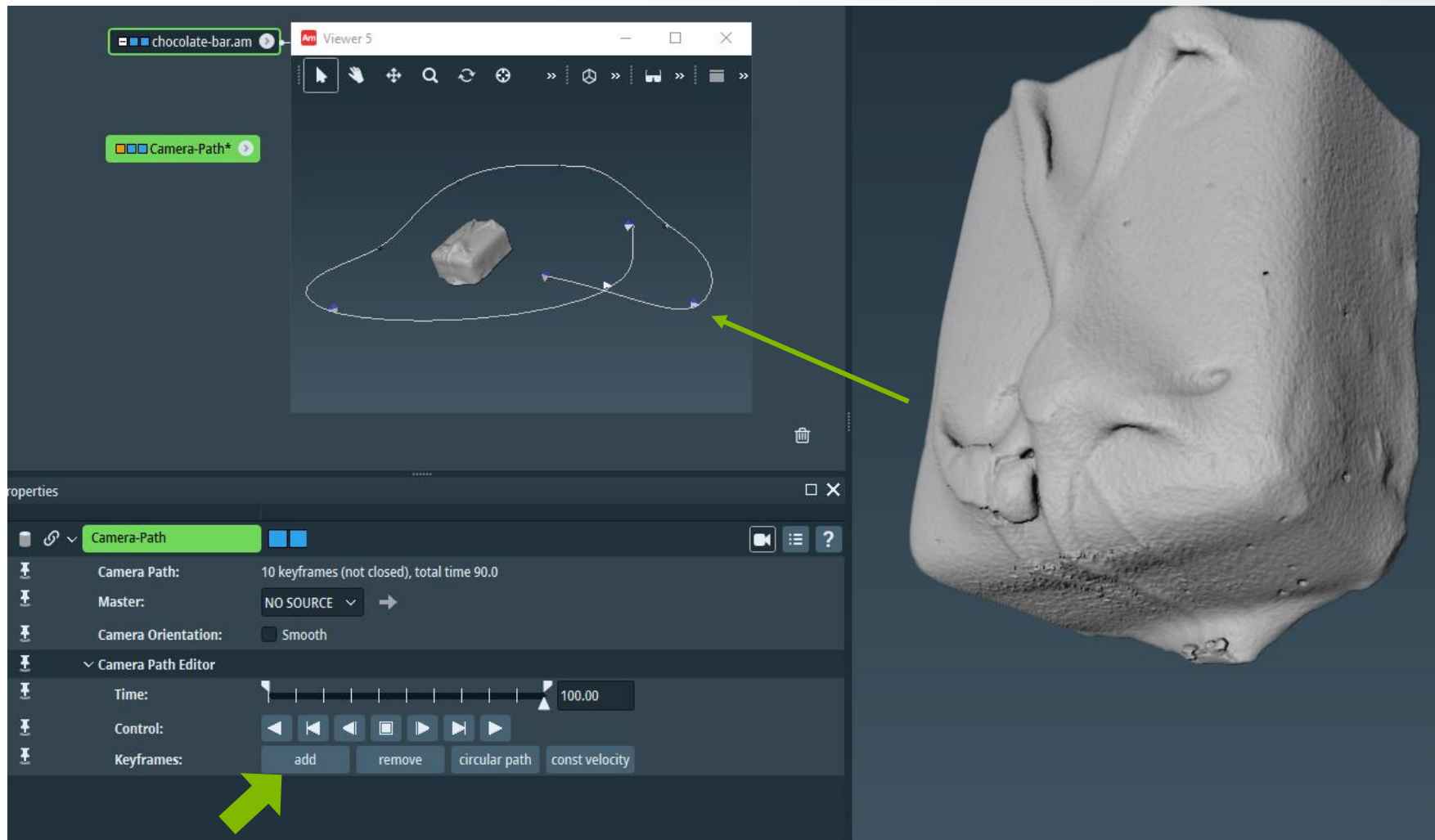
Animation: Camera Path (rotation)

Camera Path

Click **Add** to start adding key frames

For each key frame;

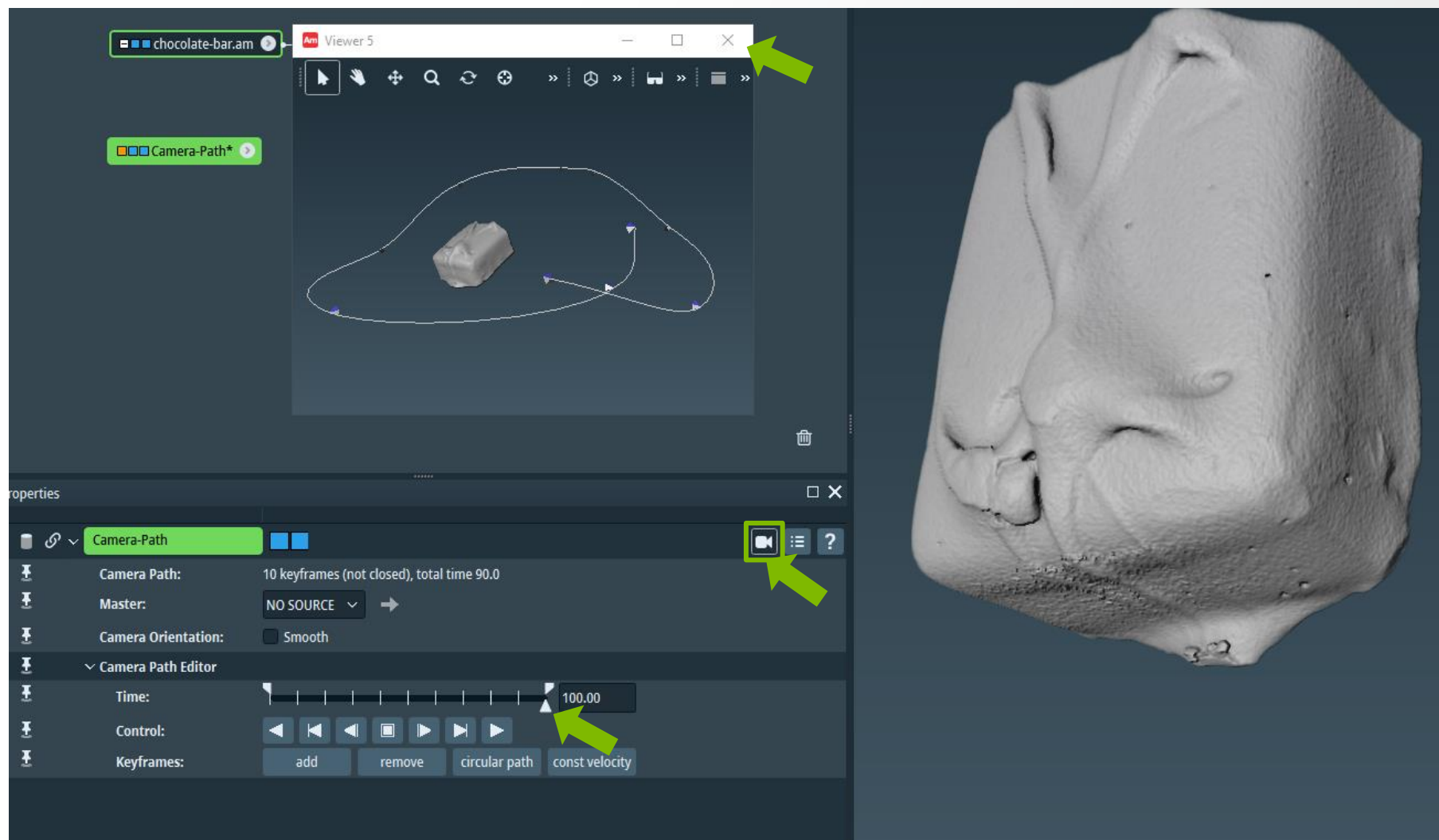
- Turn, rotate, zoom data in or out
- The path of camera rotation will be shown in the small Camera Path Viewer



Animation: Camera Path (rotation)

Camera Path

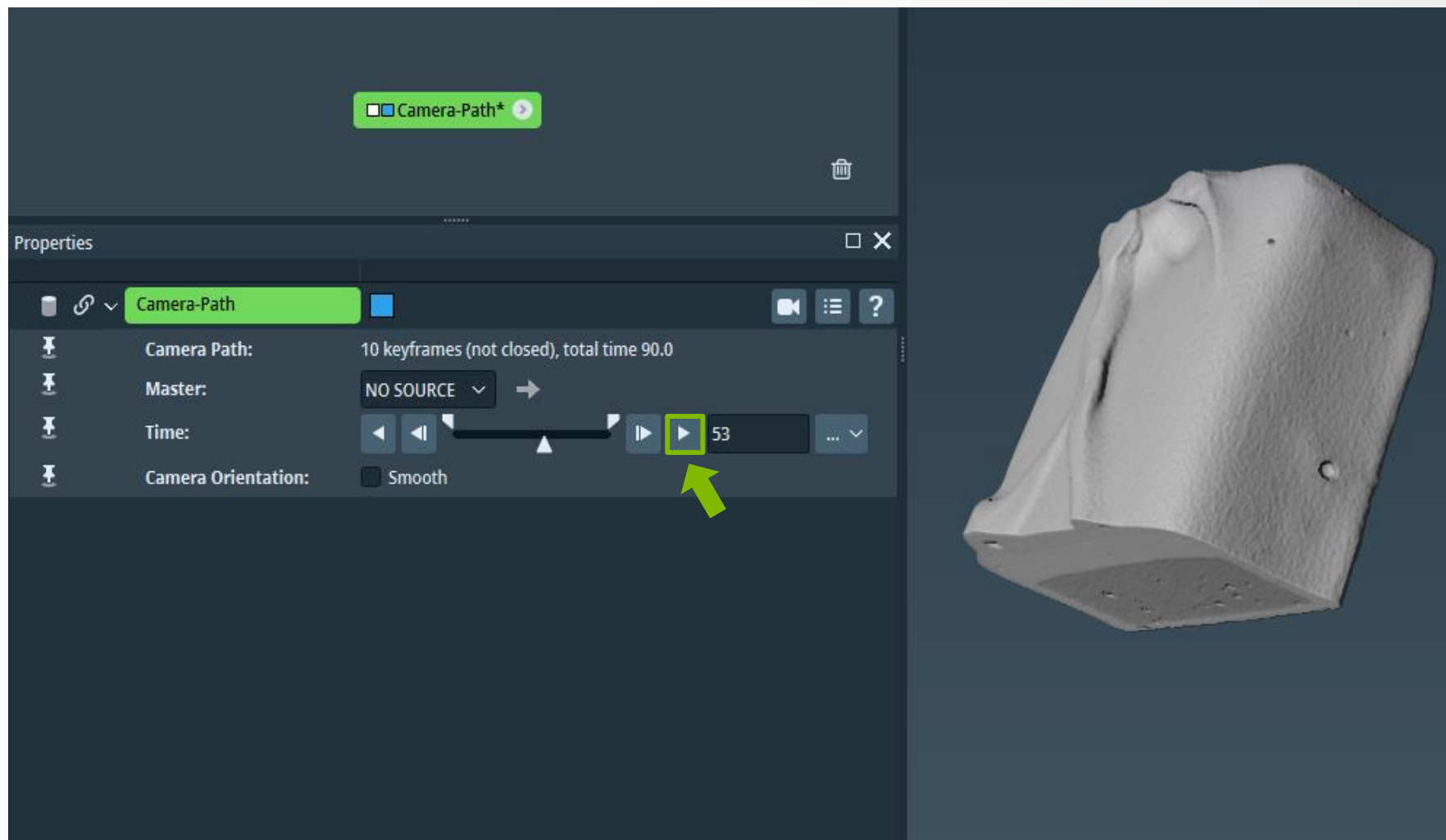
Click the small viewer to close **Camera Path Editor** when finish with key frames (or click at the **Camera Editor** icon one more time).



Animation: Camera Path (rotation)

Camera Path

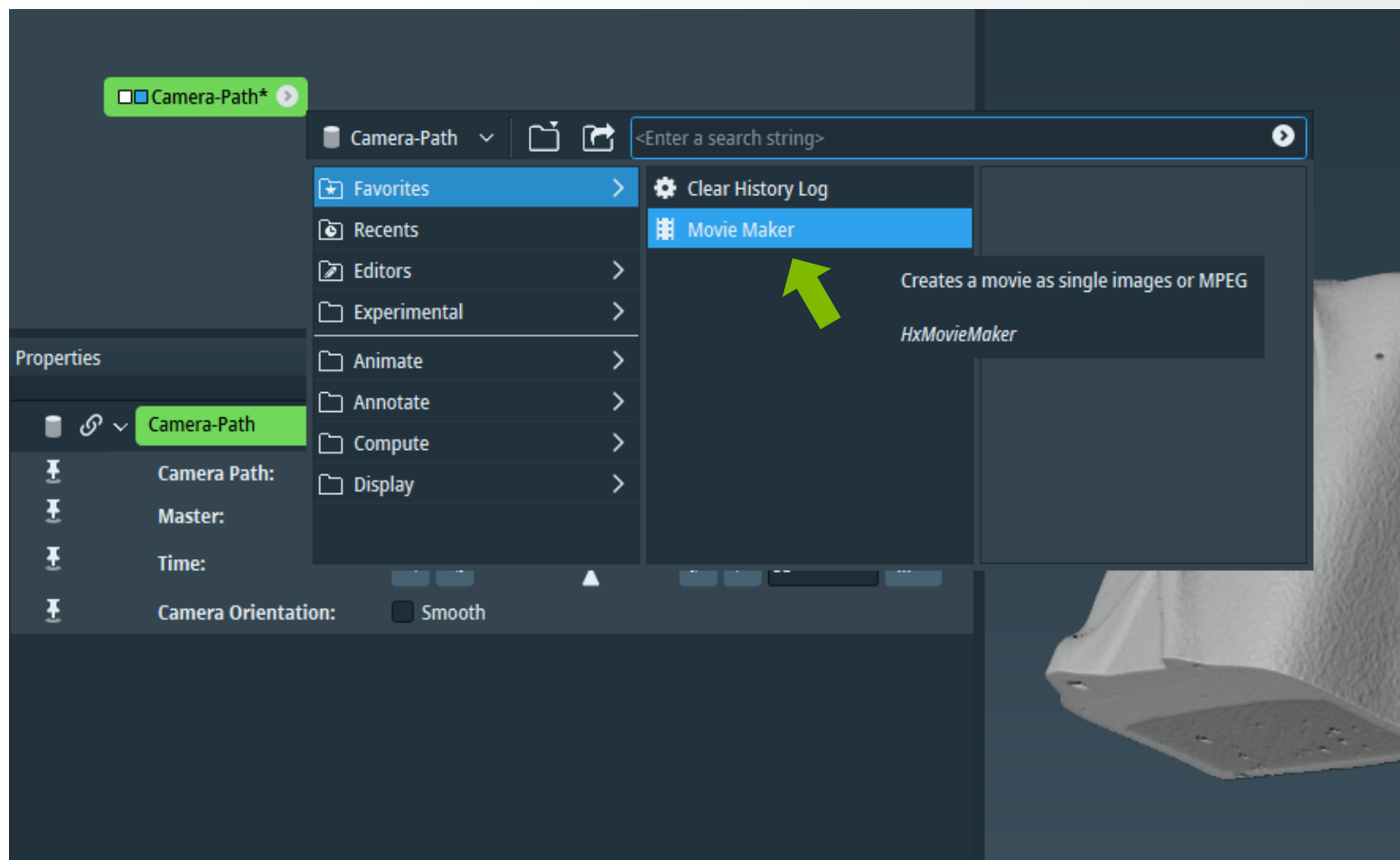
Click **Play** button to preview the animation



Animation: Camera Path (rotation)

Making movie

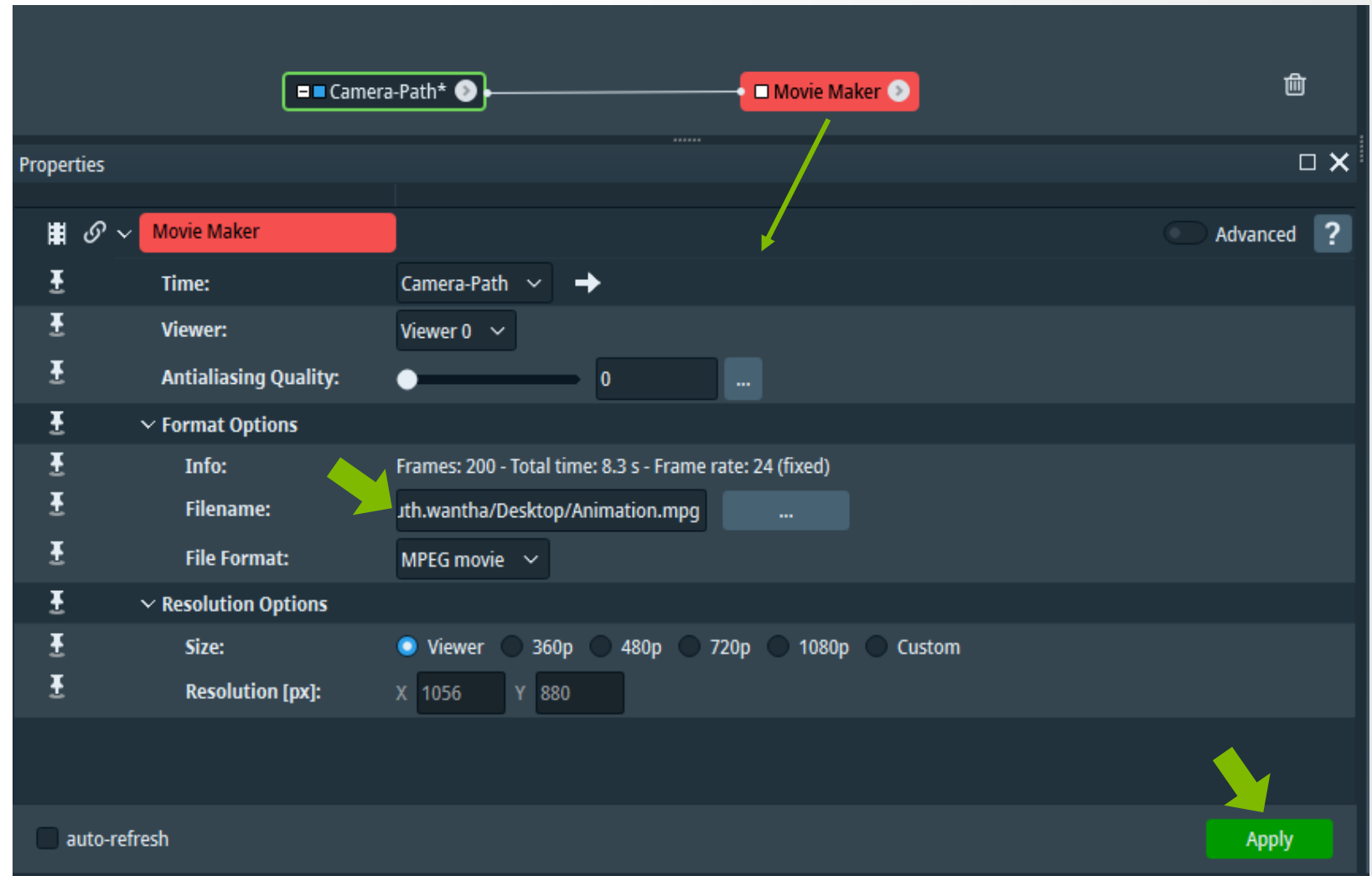
Right click at **Camera-Path** module to attach **Movie Maker** module



Animation: Camera Path (rotation)

Movie Maker

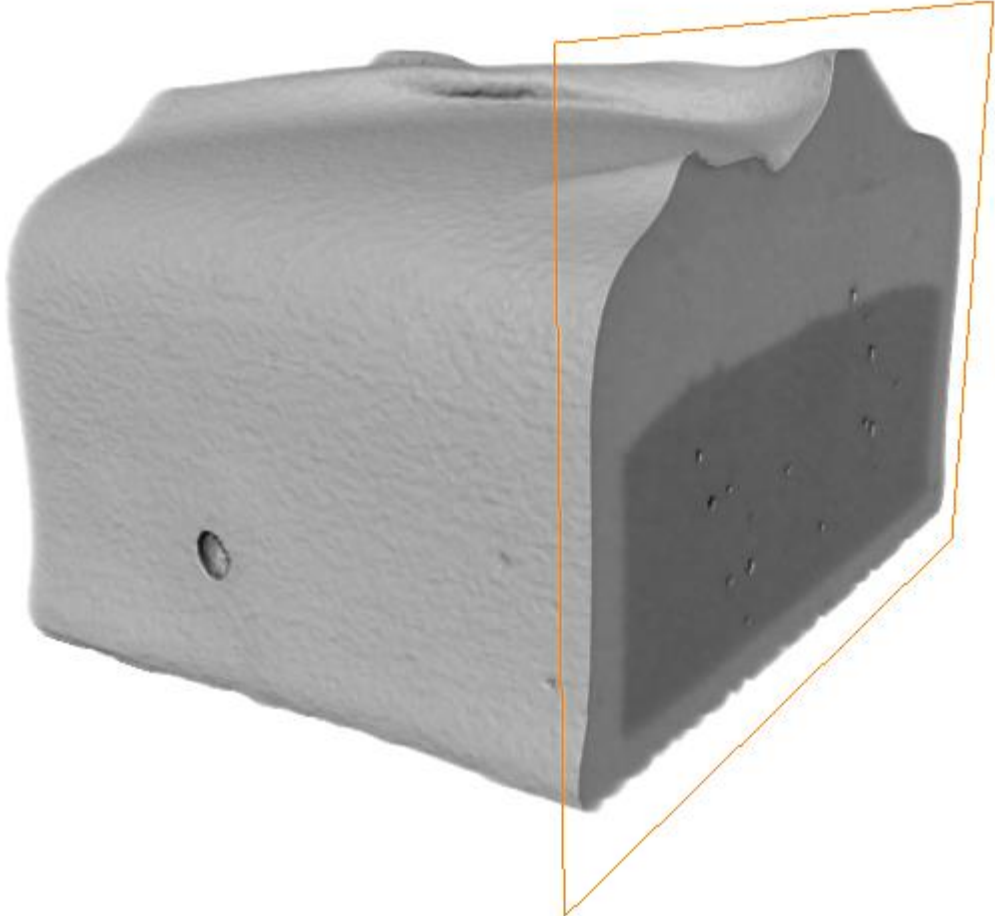
Set the parameters (Filename field is mandatory) then click **Apply** to create a movie file.



Animation: Camera Path (rotation) movie example



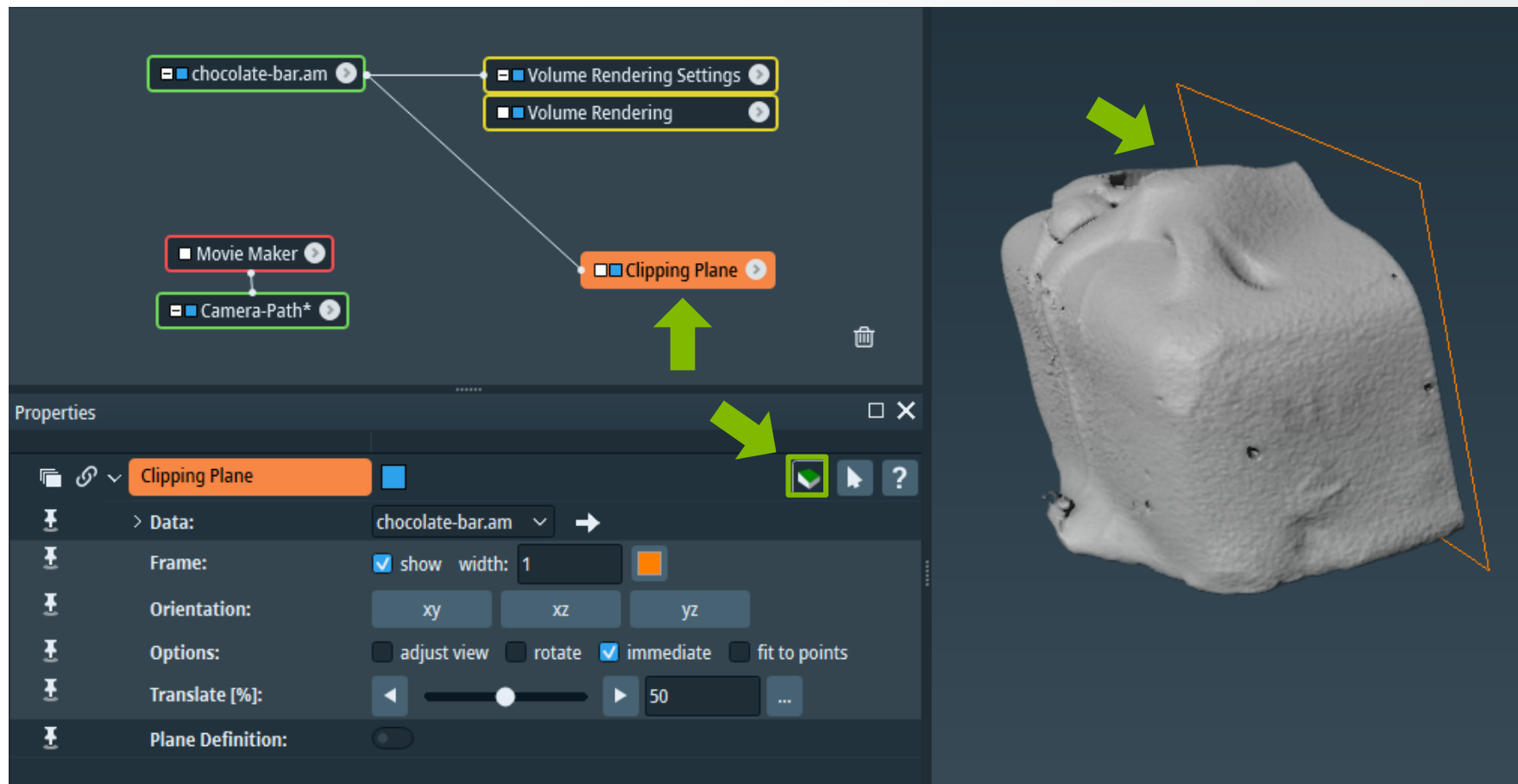
Animation Workroom: Animation Director



Animation Workroom: Animation Director

Animation Director

Attach Clipping Plane to the dataset and “clip”



Animation Workroom: Animation Director

Animation Director

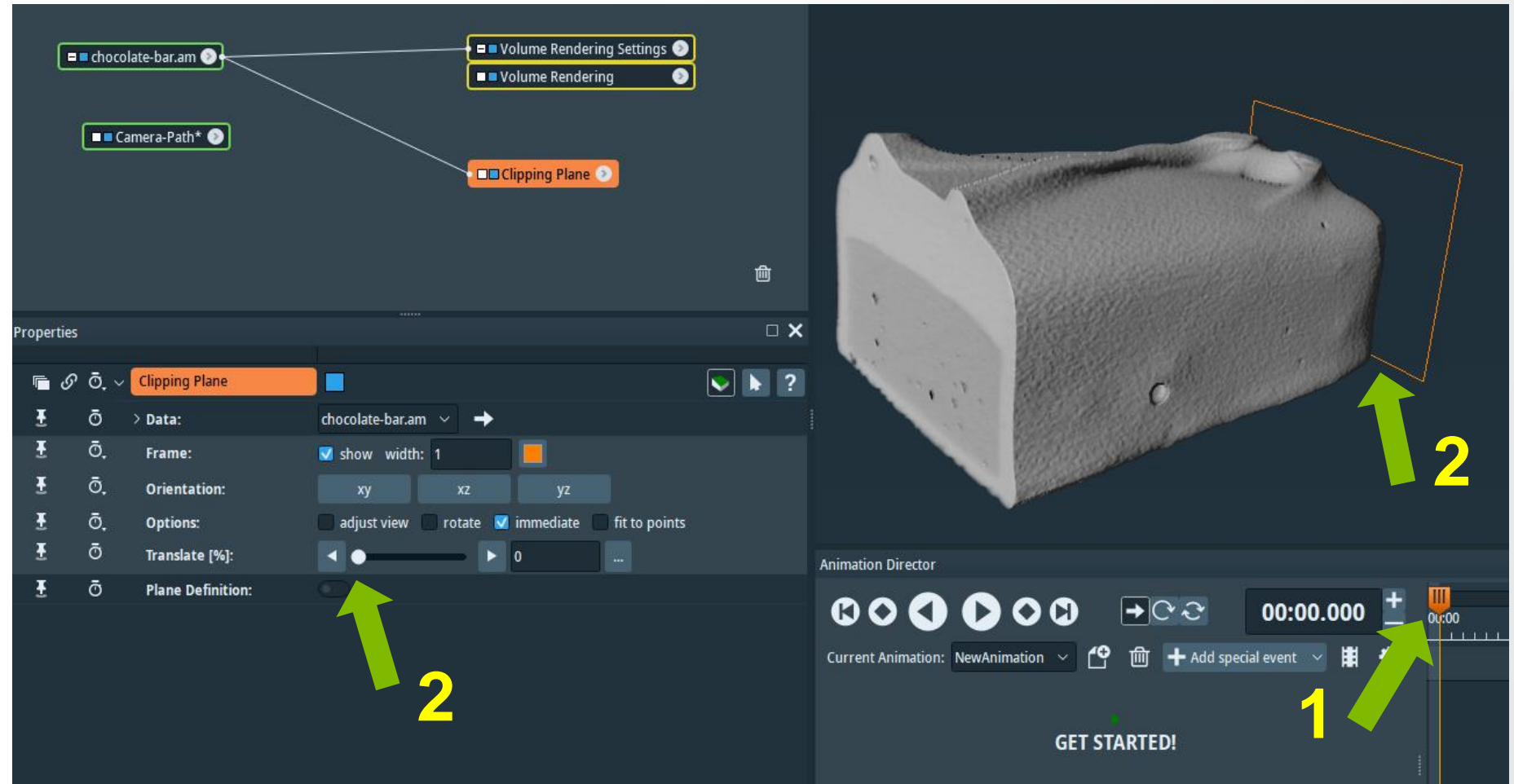
Then activate the Animation workroom. The Animation Director will appear.

The screenshot displays the software's interface with the Animation Director panel activated. A green arrow points to the 'Animation' tab in the top menu bar. Another green arrow points to the 'Animation Director' panel at the bottom right. The 'Project View' on the left shows a tree structure with 'chocolate-bar.am' selected, which is linked to 'Volume Rendering Settings', 'Volume Rendering', and 'Clipping Plane'. The 'Properties' panel at the bottom left shows settings for the 'Clipping Plane', including 'Data' (chocolate-bar.am), 'Frame' (show width: 1), 'Orientation' (xy, xz, yz), and 'Options' (adjust view, rotate, immediate, fit to points). The 'Animation Director' panel at the bottom right features playback controls (play, stop, back, forward, reset), a time display (00:00.000), and a timeline. A 3D model of a chocolate bar is visible in the center, with an orange wireframe box around it. A 'GET STARTED!' message is displayed in the Animation Director panel, stating: 'The current Animation Director does not contain any animation. To animate a component (object, port, viewer...), click on the button located near the component to be animated.'

Animation Workroom: Animation Director

Translation Animation

1. Start with the Timeline at 00:00:000
2. In Clipping Plane Properties translate to 0%. Pay attention to the clipping direction: full volume should be visible at 0% (Translate).



Animation Workroom: Animation Director

Translation Animation

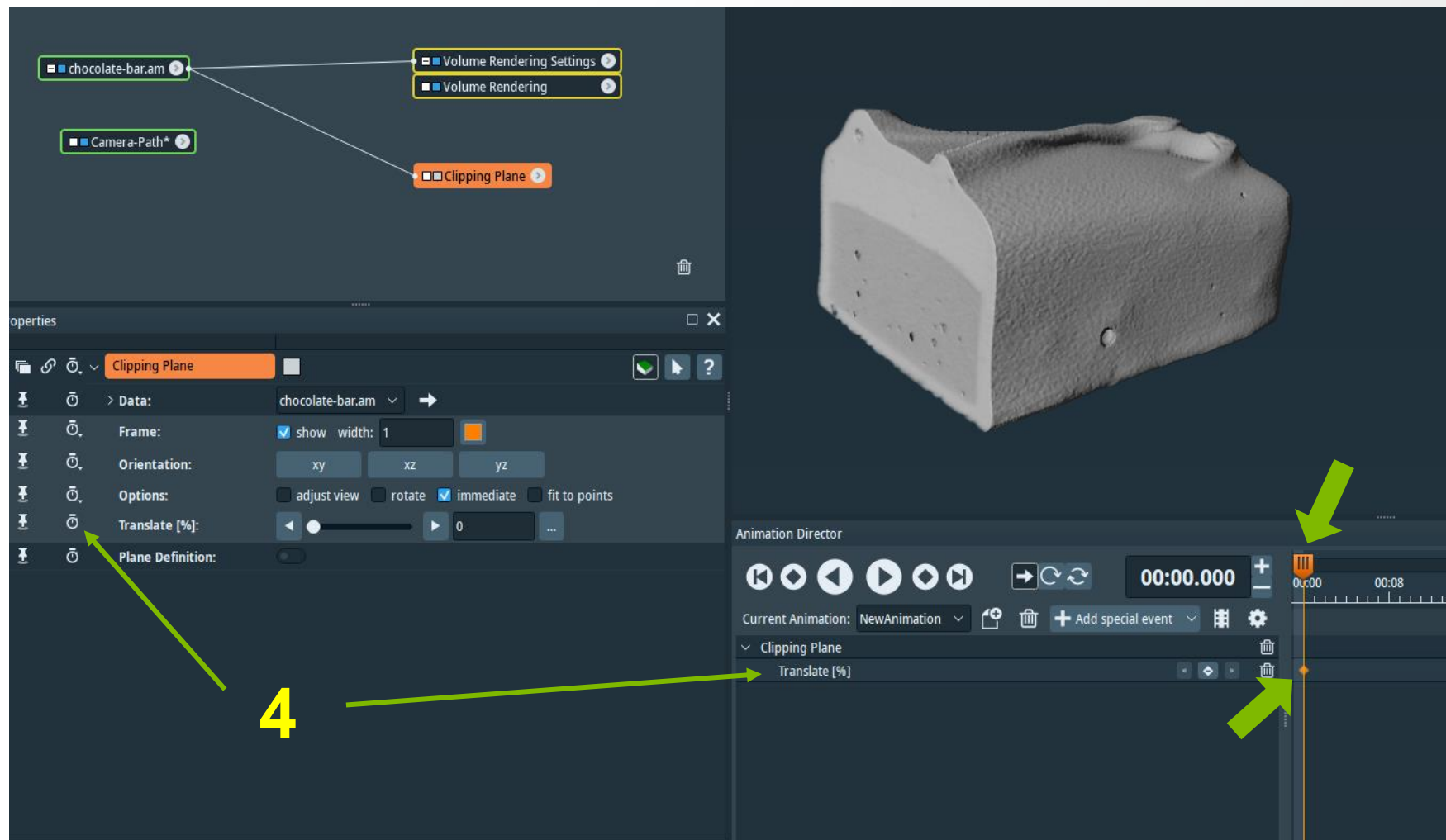
1. Start with the Timeline at 00:00:000
2. In Clipping Plane Properties. Translate to 0%
3. Hide the Clipping Plane bounding box.

The screenshot displays the Animation Director software interface. On the left, a tree view shows a hierarchy of objects: 'chocolate-bar.am' (highlighted in green), 'Camera-Path*' (highlighted in green), 'Volume Rendering Settings', 'Volume Rendering', and 'Clipping Plane' (highlighted in orange). A yellow number '3' is placed between two green arrows: one points from the 'Clipping Plane' object in the tree to the 'Clipping Plane' property in the Properties panel, and the other points from the 'Clipping Plane' property to the 'Translate [%]' slider, which is set to 0. The Properties panel for 'Clipping Plane' includes fields for Data (chocolate-bar.am), Frame (show width: 1), Orientation (xy, xz, yz), Options (adjust view, rotate, immediate, fit to points), Translate [%] (0), and Plane Definition. On the right, a 3D model of a chocolate bar is shown. At the bottom, the Animation Director control bar features playback controls (stop, play, next, previous, home, end), a timeline showing 00:00.000, and a 'GET STARTED!' button. Below the button, a message states: 'The current Animation Director does not contain any animation. To animate a component (object, port, viewer...), click on the [icon] button located near the component to be animated.'

Animation Workroom: Animation Director

Translation Animation

4. Click the **Stopwatch** button next to **Translate (%)** in **Clipping Plane** properties to start adding the first key frame (Translation) to the timeline at 00:00:00.



Animation Workroom: Animation Director

Translation Animation

5. Move the timeline bar to 00:03:000
6. Translate to 50 %
7. Add a key frame

The screenshot displays the Animation Director interface. On the left, a 3D view shows a grey, textured chocolate bar wrapper. The right side features a Properties panel for the 'Clipping Plane' object, which is currently set to 'chocolate-bar.am'. The 'Translate [%]' property is set to 50. Below the Properties panel is the Animation Director timeline, which is set to 00:03.000. A key frame is visible on the timeline for the 'Translate [%]' property. Three yellow arrows with numbers 5, 6, and 7 point to the timeline, the 'Translate [%]' slider, and the key frame icon, respectively.

Animation Workroom: Animation Director

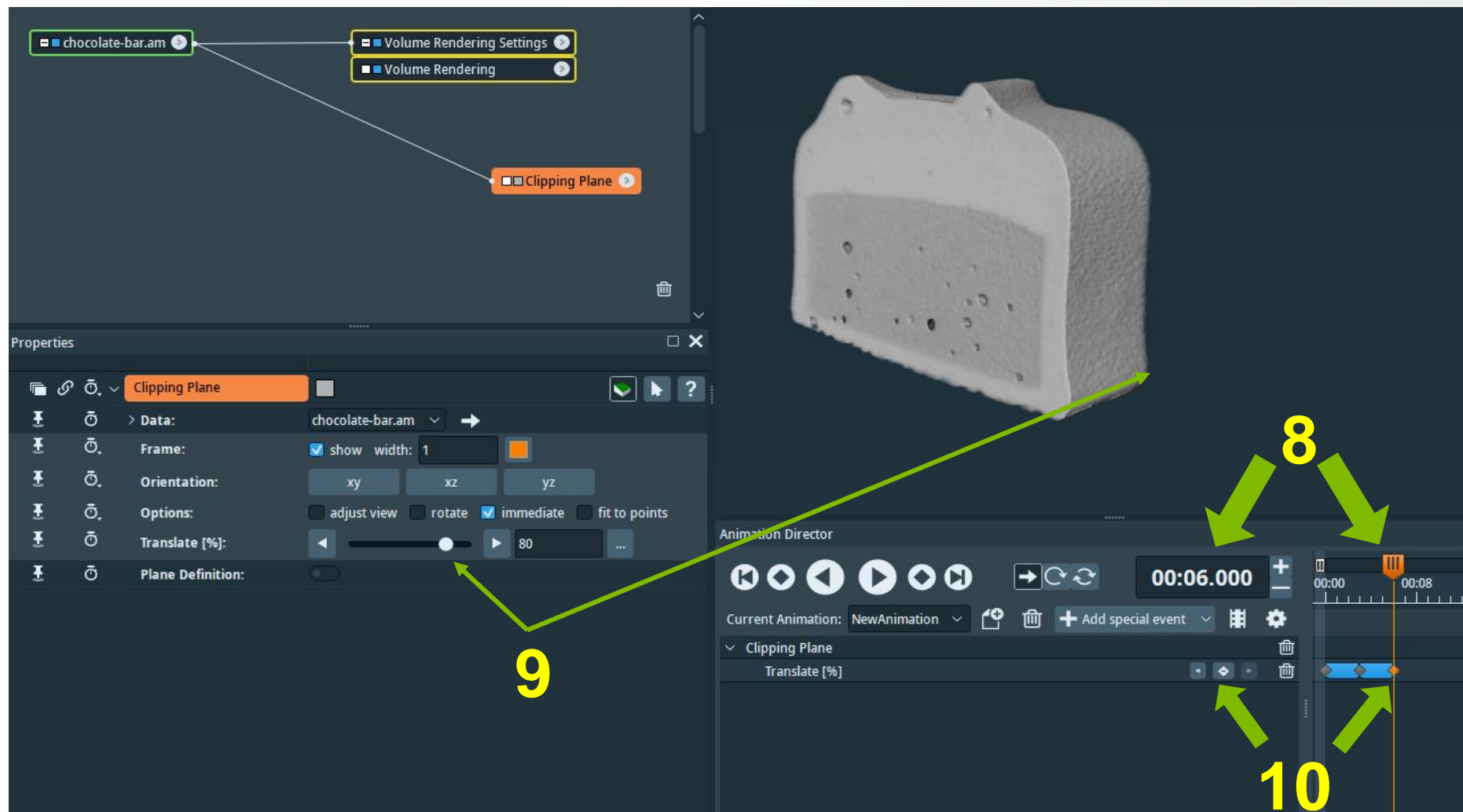
Translation Animation

Repeat the steps

8. Move the timeline bar to 00:06:000

9. Translate to 80 %

10. Add a key frame



Animation Workroom: Animation Director

Translation Animation

Repeat the steps

11. Move the timeline bar to 00:09:000

12. Translate to 0 %

13. Add a key frame

The screenshot displays the Animation Director interface. On the left, the Properties panel shows the 'Clipping Plane' settings for the 'chocolate-bar.am' object. The 'Translate [%]' slider is set to 0. A green arrow points from this slider to the timeline bar at 00:09:000. The timeline bar is labeled with a yellow '11'. Below the timeline bar, the 'Add key frame' button is labeled with a yellow '13'. The 'Translate [%]' slider is labeled with a yellow '12'. The 3D model of the chocolate bar is shown in the center, with a green arrow pointing from the 'Translate [%]' slider to it.

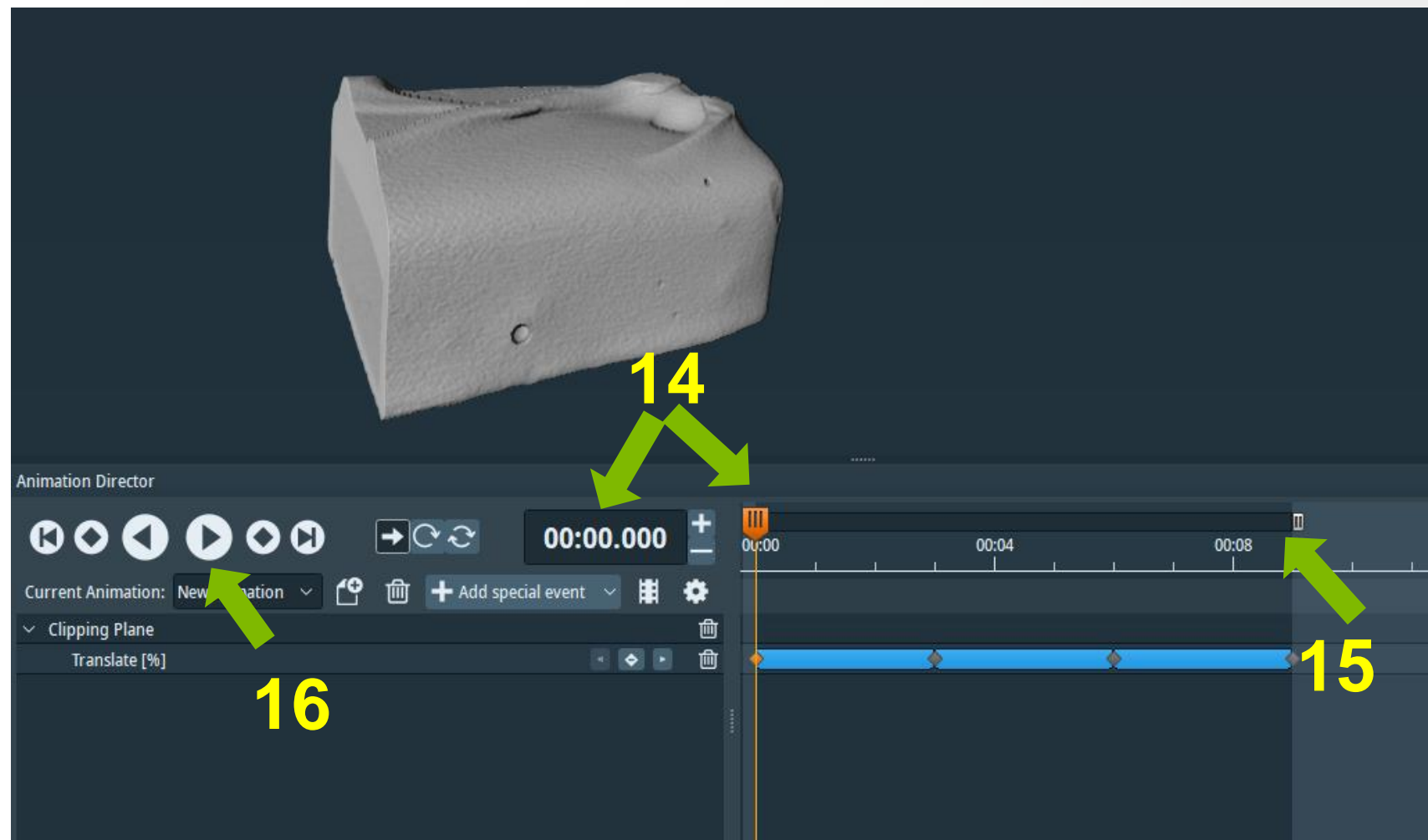
Animation Workroom: Animation Director

Translation Animation

14. When done, bring timeline bar to 00:00:00

15. Set the limit of the animation at 00:09:00

16. Click Play button in Animation Director to preview the animation.



Animation Workroom: Animation Director

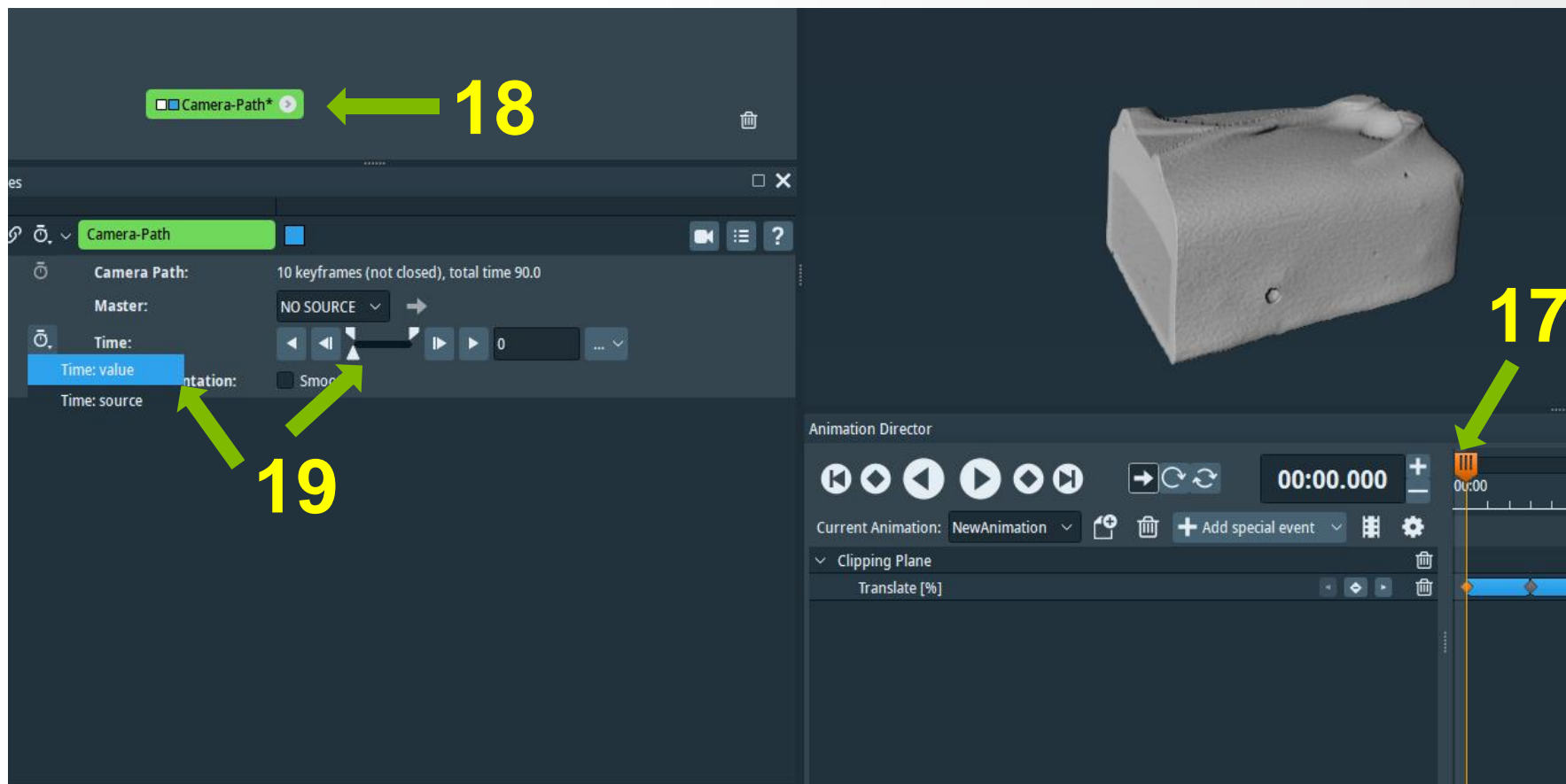
Translation + Rotation Animation

17. At time 00:00:000

18. Click on **Camera-Path** module (with previously created rotation key frames).

19. Make sure to have Time 0 in **Camera Path** properties port before clicking on **Stopwatch** button next to Time.

Select **Time value** to add to Animation Workroom.



Animation Workroom: Animation Director

Translation + Rotation Animation

17. At time 00:00:000

18. Click at **Camera-Path** module (with previously created rotation keyframes).

19. Make sure to have Time 0 in **Camera Path** properties port before clicking on **Stopwatch** button next to Time.

Select **Time value** to add to Animation Workroom.

The screenshot displays the Animation Director software interface. On the left, the Properties panel shows the 'Camera-Path' module selected, with a green arrow labeled '18' pointing to the 'Camera-Path+' button. The 'Time' field is set to '0', and a green arrow labeled '19' points to the 'Stopwatch' button next to it. On the right, the Animation Director panel shows a timeline with a blue bar representing the animation. A green arrow labeled '17' points to the 'Stopwatch' button in the Animation Director panel. The main view shows a 3D model of a white rectangular object.

Animation Workroom: Animation Director

Translation + Rotation Animation

20. Move the timeline bar to 00:03:000

21. Move Camera Path Key frame to time 30

22. Add a key frame

The screenshot displays the Animation Director interface. On the left, a 3D view shows a white chocolate bar wrapper. The right side features the Animation Director controls, including a timeline bar set to 00:03.000. The Properties panel for the Camera-Path animation is visible, showing 8 keyframes and a total time of 70.0. The timeline bar is highlighted with a yellow '20' and an arrow pointing to the 00:03.000 mark. The Camera Path keyframe at time 30 is highlighted with a yellow '21' and an arrow. A yellow '22' with an arrow points to the 'Add keyframe' button in the Properties panel. The Animation Director panel also shows a yellow '22' with an arrow pointing to the 'Add keyframe' button.

Animation Workroom: Animation Director

Translation + Rotation Animation

Repeat the steps

23. Move the timeline bar to 00:06:000

24. Move Camera Path Key frame to time 60

25. Add a key frame

The screenshot displays the Animation Director interface. On the left, a 3D view shows a chocolate bar. The Properties panel for 'Camera-Path' is visible, showing '8 keyframes (not closed), total time 70.0' and a 'Time' field set to '60'. The Animation Director panel at the bottom shows a timeline with a current time of '00:06.000'. A green arrow labeled '23' points from the timeline bar to the 'Time' field in the Properties panel. Another green arrow labeled '24' points from the 'Time' field in the Properties panel to the timeline bar. A third green arrow labeled '25' points from the timeline bar to the 'Time: value' field in the Animation Director panel.

Animation Workroom: Animation Director

Translation + Rotation Animation

Repeat the steps

26. Move the timeline bar to 00:09:000

27. Move Camera Path Key frame to time 90

28. Add a key frame

The screenshot displays the Animation Director interface. On the left, a scene view shows a 3D model of a chocolate bar. The top-left panel contains a hierarchy of objects: 'chocolate-bar.am', 'Volume Rendering Settings', 'Volume Rendering', 'Camera-Path*', and 'Clipping Plane'. The 'Properties' panel for 'Camera-Path' shows '8 keyframes (not closed), total time 70.0', 'Master: NO SOURCE', 'Time: 70', and 'Camera Orientation: Smooth'. The 'Animation Director' panel at the bottom features a timeline with a playhead at 00:09.000. A large yellow arrow labeled '26' points to the playhead. Another yellow arrow labeled '27' points to the 'Time' field in the 'Camera-Path' properties. A third yellow arrow labeled '28' points to the 'Add special event' button in the 'Animation Director' panel.

Animation Workroom: Animation Director

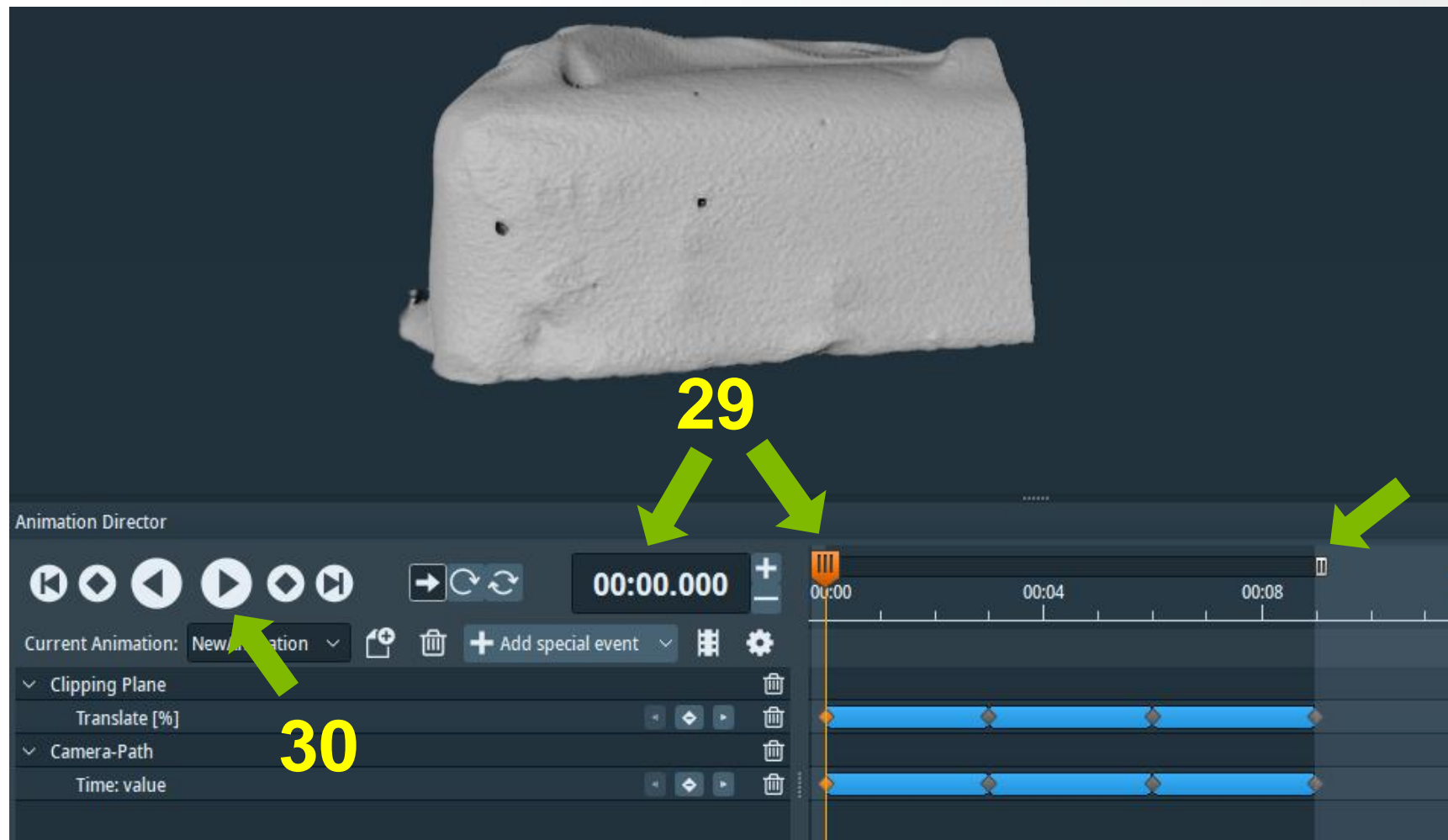
Translation + Rotation

Animation

29. When done, bring timeline bar to 00:00:00

30. Click Play button in **Animation Director** to preview the animation.

Please note that the animation limit was already set at 00:09:00

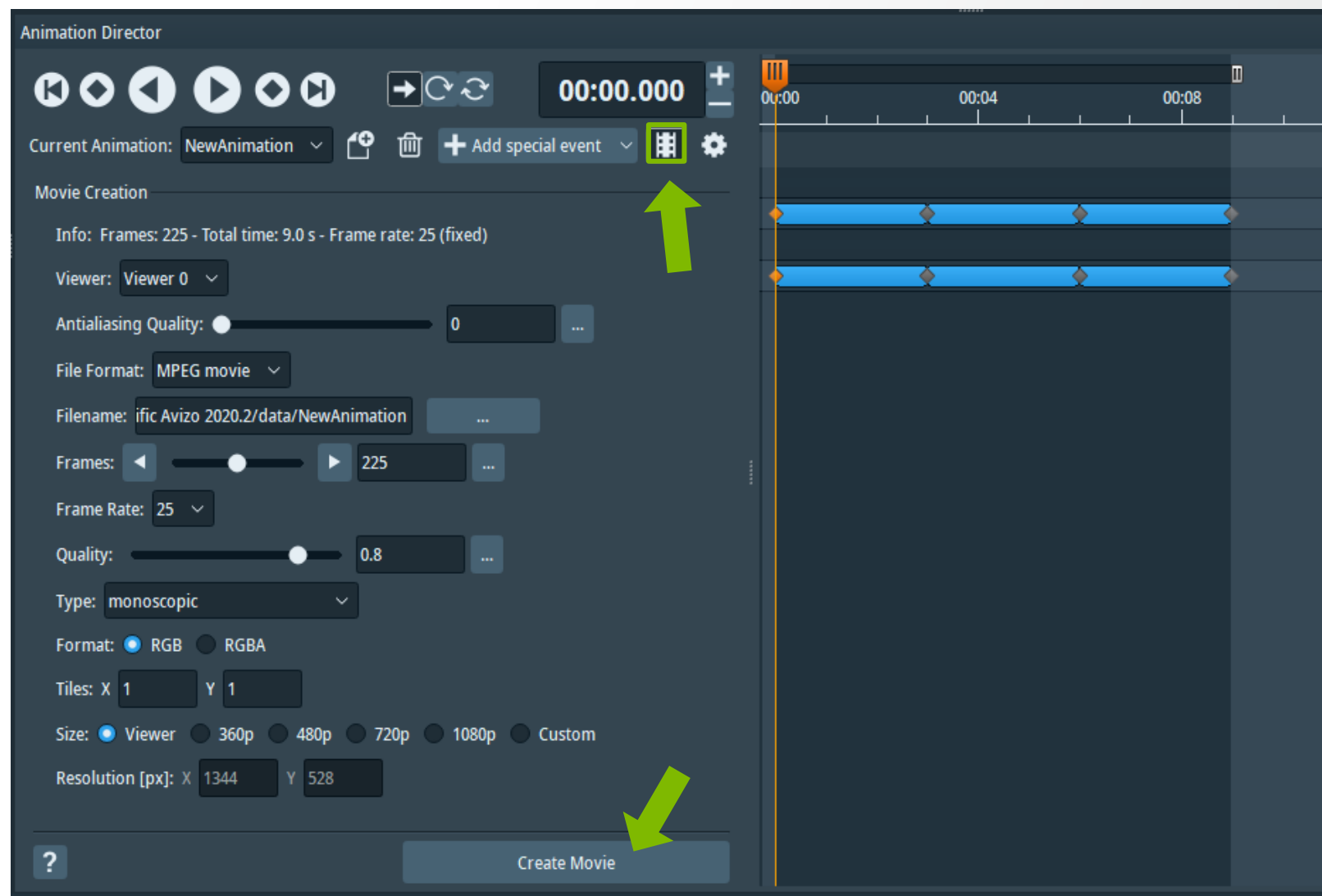


Animation director: movie generator

Movie Creation

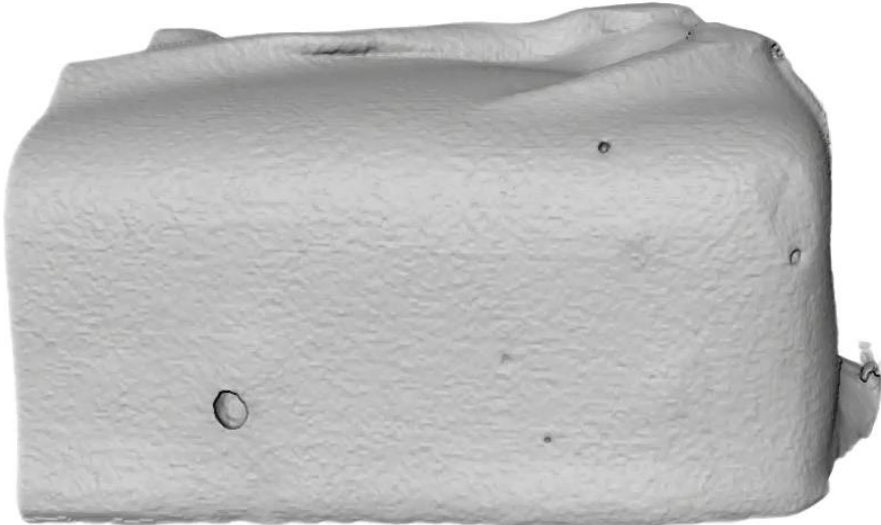
Activate **Movie Creation** in **Animation Director** and input all parameters as needed.

Then click **Create Movie**.



The screenshot displays the 'Animation Director' software interface. The top toolbar includes playback controls (stop, play, next, previous, refresh) and a time display showing '00:00.000'. Below the toolbar, the 'Current Animation' is set to 'NewAnimation'. A green arrow points to the 'Add special event' button, which is highlighted with a green box. The 'Movie Creation' section is active, showing various settings: 'Info: Frames: 225 - Total time: 9.0 s - Frame rate: 25 (fixed)', 'Viewer: Viewer 0', 'Antialiasing Quality: 0', 'File Format: MPEG movie', 'Filename: ific Avizo 2020.2/data/NewAnimation', 'Frames: 225', 'Frame Rate: 25', 'Quality: 0.8', 'Type: monoscopic', 'Format: RGB', 'Tiles: X 1 Y 1', 'Size: Viewer', and 'Resolution [px]: X 1344 Y 528'. A green arrow points to the 'Create Movie' button at the bottom right of the settings panel. The right side of the interface shows a timeline with a vertical orange line at 00:00 and two blue horizontal bars representing animation segments.

Animation Workroom: Animation Director movie example



Thank you!

Find out more at thermofisher.com/avizo

