


Region of Interest (ROI)

Method note MCT-131

1. Introduction

Region of interest is a user defined region within the entire acquired image volume which the user is interested in. This reduces the total image volume and thus save disk space or allow faster processing of further analysis. The terms “region of interest” (ROI) and “volume of interest” (VOI) are frequently used interchangeably. To be exact, ROI means a selected region on a single cross-section in 2D, while “VOI” means the ROIs on many consecutive slices making a selected volume. But “ROI” is often used to mean a selected volume like VOI – so users should decide for themselves how to use these terms.

CTan provides a region of interest (ROI) tool which allows users to selectively define areas in which to conduct analysis or processing. The ROI tool can be activated by selecting the  **Regions of interest preview** icon via the tool bar, via the tab **View -> Regions of interest** or using the shortcut key **Alt+2**.

2. Options available in ROI tool bar



After activating Regions of interest, a ROI tool bar will be visible with various options. By default, a ROI that covers the entire image volume is automatically created. The active ROI is seen as a red overlay over either the raw image volume of the binarized image volume.

- (1) **Load regions of interest:** Opens a previously saved ROI file for use in the currently opened image volume.
- (2) **Load image as ROI:** Opens a saved (binary) image file for use as the ROI in the currently opened image volume.

- (3) **Save regions of interest:** Saves the current ROI as a single xxx.roi file that can be only be opened with CTan.

- (4) **Save new dataset from ROI:** Saves the dataset within the ROI as a new dataset. Several sub-options are also available. **Create folder named VOI** allows users to automatically create a VOI folder in which the new dataset will be saved. **Save ROI-file** allows users to concurrently save the ROI file as a single xxx.roi file. **Save overlay images** saves the original image with the ROI saved as a red overlay on top of the original image. The ROI cannot be further edited when the overlay images are reopened in CTan. **Background** allows user to either set the area outside of the ROI to black or white. Additional options for saving dataset from ROI can be found in Preferences. Under Save images, users can choose to save the full extent of the image data (Full area) or a reduced volume defined by the boundaries of the ROI (Inside accumulated ROI bounds).

- (5) **Cut ROI:** Cut ROI from current slice, current ROI will be removed from current slice

- (6) **Copy ROI:** Copy ROI from current slice, current ROI will be kept

- (7) **Paste ROI:** Cut/copy ROI from current slice and paste ROI onto next selected slice

- (8) **Edit Polygonal ROI:** Manually adjust the position of vertices of a polygonal ROI. An upward pointing arrow is displayed over the selected vertex and the vertex can be selected with a left click and moved to a new location. With the upward pointing arrow displayed, a right-click will allow removal of that node. Likewise, when the cursor covers the ROI boundary away from a node, it will show as a cross and allow a new node to be added.

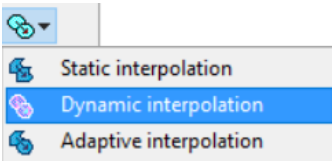
- (9) **Polygonal region of interest:** Create specific shaped ROIs. These include shapes such as **Rectangle**, **Square**, **Elliptic**, **Round** and **Polygonal**. **Empty** will

remove all ROI from current slice. **Interpolated** will calculate the ROI of the current slice from neighboring slices. Interpolated is the default state of all cross-sections until they are set to be otherwise; interpolation will be further discussed in later section. **Image** changes editable polygons into shapes that cannot be further edited using the Edit Polygonal ROI. Image can however be further edited by another method which will be discussed later.

- (10) **Additional Polygonal region of interest:** create extra polygonal shaped ROIs. **Rectangle**, **Elliptic** and **Polygonal** can be selected. Alternatively, **Alt+R/E/P** can be used to select the different ROI shapes. Hold onto **Shift** and click the **right mouse button** to add the extra ROI. On the other hand, hold onto **Ctrl** and click the **right mouse button** to remove part of a ROI with the chosen polygonal shape. After editing, the composite ROI cannot be edited using the **Edit Polygonal ROI** option.
- (11) **Expand region of interest to image:** Enlarge ROI in current slice such that the furthest edges of the ROI touch the edge of the image.
- (12) **Copy region of interest to all images:** Copy the ROI in current slice to all slices.
- (13) **Reset all regions of interest:** Sets regions of interest to default mode i.e. ROI covers entire image volume. In other words, delete all ROI shapes and go back to the default – full dataset selected over the specified range of slices.
- (14) **Subtractive ROI:** Inverts the selection of ROI such that everything that was not defined as the ROI previously is now defined as the ROI and vice versa.
- (15) **Interpolation:** Interpolation allows users to self-define a small number of ROIs on key image slices across a large image volume and an interpolation algorithm will be used to fill in the ROIs in between these self-defined key ROIs. 3 interpolation methods are available, they are static, dynamic and adaptive.

3. Interpolation

There are 3 types of interpolation available. They are **static**, **dynamic** and **adaptive**. These are different ways (algorithms) for interpolating between different shapes on different levels. The last button on the ROI button bar gives



a drop menu of these three interpolation options. Static interpolation uses an older interpolation method that may introduce obvious discontinuity within the interpolated regions and its use is not encouraged. Dynamic and adaptive interpolation produces smoother transition across interpolated regions and are recommended for general application. Where highly detailed ROIs are drawn on many slices, static interpolation is more precise, however (but it fails to interpolate between non-overlapping shapes).

3.1. Copying or interpolating over a range of cross-sections

You can copy the ROI on one level to a range of neighboring slices.

In this example an ROI has been loaded from binary images so all cross-sections have “image” format. I apply manual edits to slices 3480 and 3470. Now I wish to interpolate the ROI for all slices between these levels.

Raw images Regions of interest Custom processing		
File name	ROI type	
35-1-left_metaph_3481.bmp	Image ROI	
35-1-left_metaph_3480.bmp	Polygonal ROI	
35-1-left_metaph_3479.bmp	Image ROI	
35-1-left_metaph_3478.bmp	Image ROI	
35-1-left_metaph_3477.bmp	Image ROI	
35-1-left_metaph_3476.bmp	Image ROI	
35-1-left_metaph_3475.bmp	Image ROI	
35-1-left_metaph_3474.bmp	Image ROI	
35-1-left_metaph_3473.bmp	Image ROI	
35-1-left_metaph_3472.bmp	Image ROI	
35-1-left_metaph_3471.bmp	Image ROI	
35-1-left_metaph_3470.bmp	Polygonal ROI	
35-1-left_metaph_3469.bmp	Image ROI	

The way to interpolate all image-format slices between these edited levels is the following. Select the slice just below the top edited slice, that is, slice number 3479, and set it to interpolated status (*ALT-delete* on the keyboard will do this):

Raw images Regions of interest Custom processing		
File name	ROI type	
35-1-left_metaph_3481.bmp	Image ROI	
35-1-left_metaph_3480.bmp	Polygonal ROI	
35-1-left_metaph_3479.bmp	Interpolated ROI	
35-1-left_metaph_3478.bmp	Image ROI	
35-1-left_metaph_3477.bmp	Image ROI	
35-1-left_metaph_3476.bmp	Image ROI	
35-1-left_metaph_3475.bmp	Image ROI	
35-1-left_metaph_3474.bmp	Image ROI	
35-1-left_metaph_3473.bmp	Image ROI	
35-1-left_metaph_3472.bmp	Image ROI	
35-1-left_metaph_3471.bmp	Image ROI	
35-1-left_metaph_3470.bmp	Polygonal ROI	
35-1-left_metaph_3469.bmp	Image ROI	

Now, with slice 3479 still selected and highlighted, hold down both the SHIFT and CTRL buttons on the keyboard and select the last slice before the lower edited level; that is, click on slice 3471. This action will cause the interpolated status of slice 3479 to be copied to all slices down to level 3471. (Don't include the lower edited level itself, 3470, otherwise its edited shape would be lost by interpolation; just choose the intervening slices.) The end result looks like this:

Raw images Regions of interest Custom processing		
File name	ROI type	
35-1-left_metaph_3481.bmp	Image ROI	
35-1-left_metaph_3480.bmp	Polygonal ROI	
35-1-left_metaph_3479.bmp	Interpolated ROI	
35-1-left_metaph_3478.bmp	Interpolated ROI	
35-1-left_metaph_3477.bmp	Interpolated ROI	
35-1-left_metaph_3476.bmp	Interpolated ROI	
35-1-left_metaph_3475.bmp	Interpolated ROI	
35-1-left_metaph_3474.bmp	Interpolated ROI	
35-1-left_metaph_3473.bmp	Interpolated ROI	
35-1-left_metaph_3472.bmp	Interpolated ROI	
35-1-left_metaph_3471.bmp	Interpolated ROI	
35-1-left_metaph_3470.bmp	Polygonal ROI	
35-1-left_metaph_3469.bmp	Image ROI	

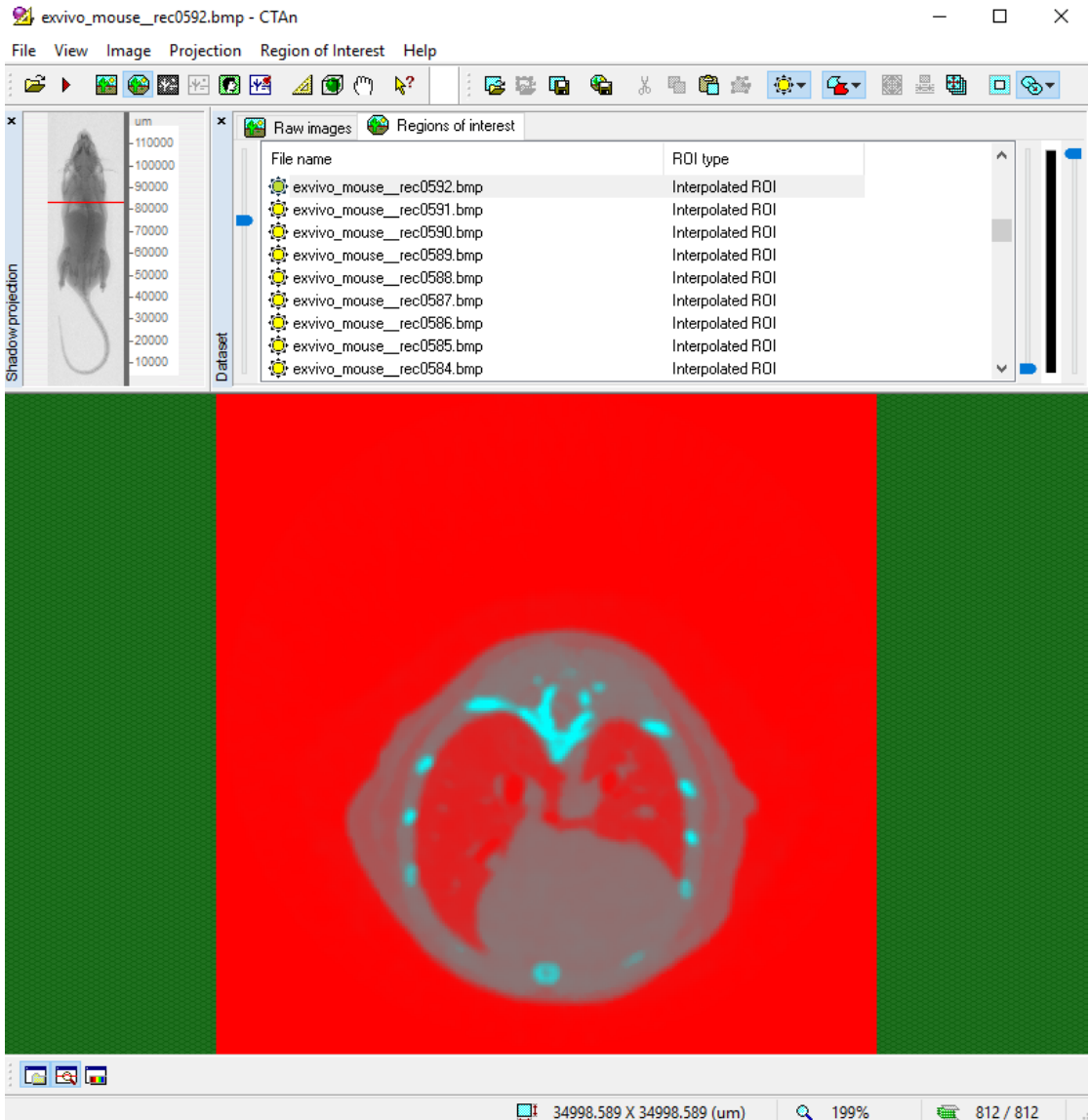
4. Example: ROI for segmentation of the lungs

In this section, we will focus on a worked example of defining an ROI for subsequent segmentation of the mouse lungs. Do take note that this example is purely for practice purpose. Below these numbered steps, there are images to illustrate the process.

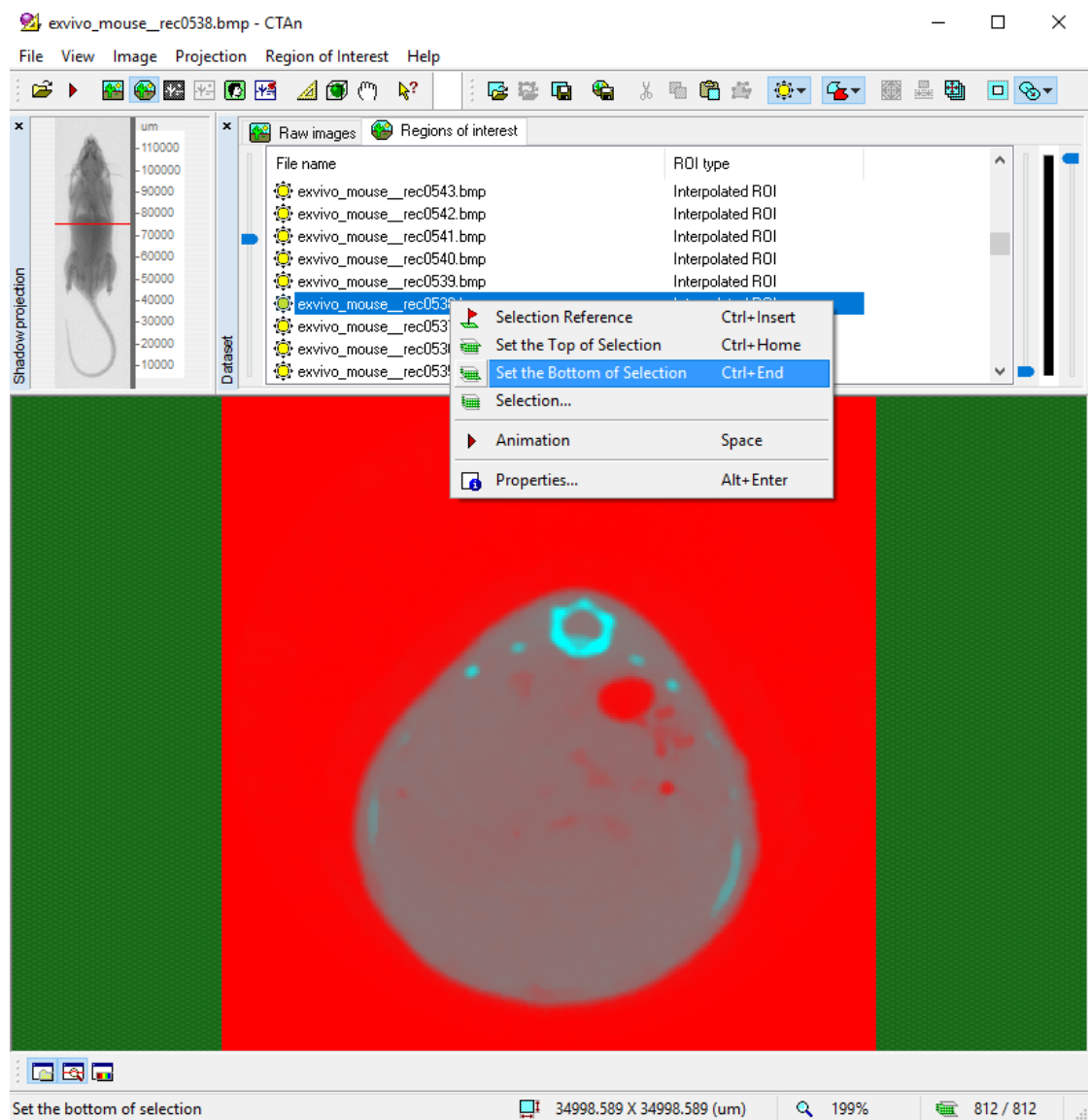
- (1) Open a mouse body dataset in **CTan**. Scrolling through the slices, the lungs has lower signal intensity thus appear darker compared to the surrounding tissues.
- (2) Activate **Regions of interest preview**. A **Regions of interest** tab opens. The window shows the ROI type of each image slice. By default, all slices will have interpolated ROI. On the image window, the ROI for the current slice will appear as a red overlay.
- (3) It is normally useful to define the top and bottom most slices that the object is confined within. Scroll through the slices to find the bottom and topmost slices that contain the images of the lungs. **Right click** on the bottom most slice and choose **Set Bottom of Selection**, do the same thing for the top slice and choose **Set Top of Selection**. This explicitly defines the volume within which the ROI can be found.
- (4) Start drawing the ROI from a slice close to the middle of the selection volume. **Left click** and drag to draw the ROI. Here, we select the **Polygonal** option for freehand drawing. After drawing the first ROI, one may scroll through the other slices and find that the interpolated ROIs on the other slices have the same shape and position.
- (5) Scroll down/up the slices from the first ROI and select a slice in which the ROI significantly mismatches the required image. Redraw the ROI by **left click** and **drag**.
- (6) After defining a new manual ROI, one can look at the ROIs between the 2 slices with manually drawn Polygonal ROIs and see that the ROI shapes

between them have changed and are now an interpolation of the 2 adjacent manually drawn ROIs. A useful shortcut for browsing through user defined ROIs involves pressing **Ctrl** and the **Up/Down** keys. Interpolation direction interpolates the slices between 2 adjacent slices by considering only the information provided by the 2 surrounding slices with manually edited ROIs and not beyond that. For a rapidly changing shape, it is necessary to have enough edited slices.

- (7) After ensuring that the ROI encompasses the required regions, the ROI can be saved by clicking on **Save regions of interest**. The ROI will be saved as a single xxx.roi file which can then be reloaded using **Load regions of interest**. **Save new dataset from ROI** can also be selected to save the raw images within the ROI as a new dataset.

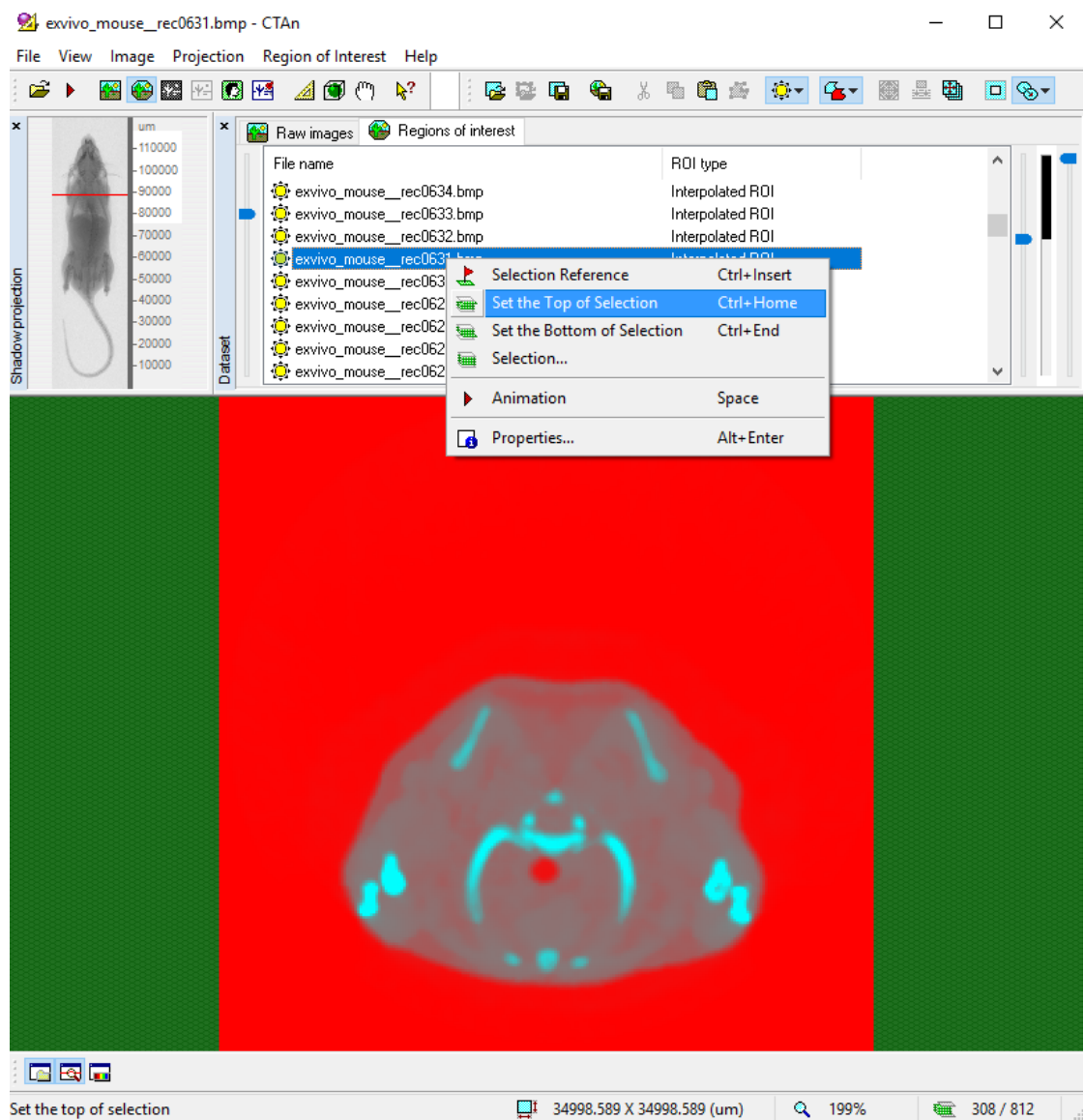


Open whole mouse body dataset and scroll to middle of lungs. Lungs region appear darker than surrounding tissues.



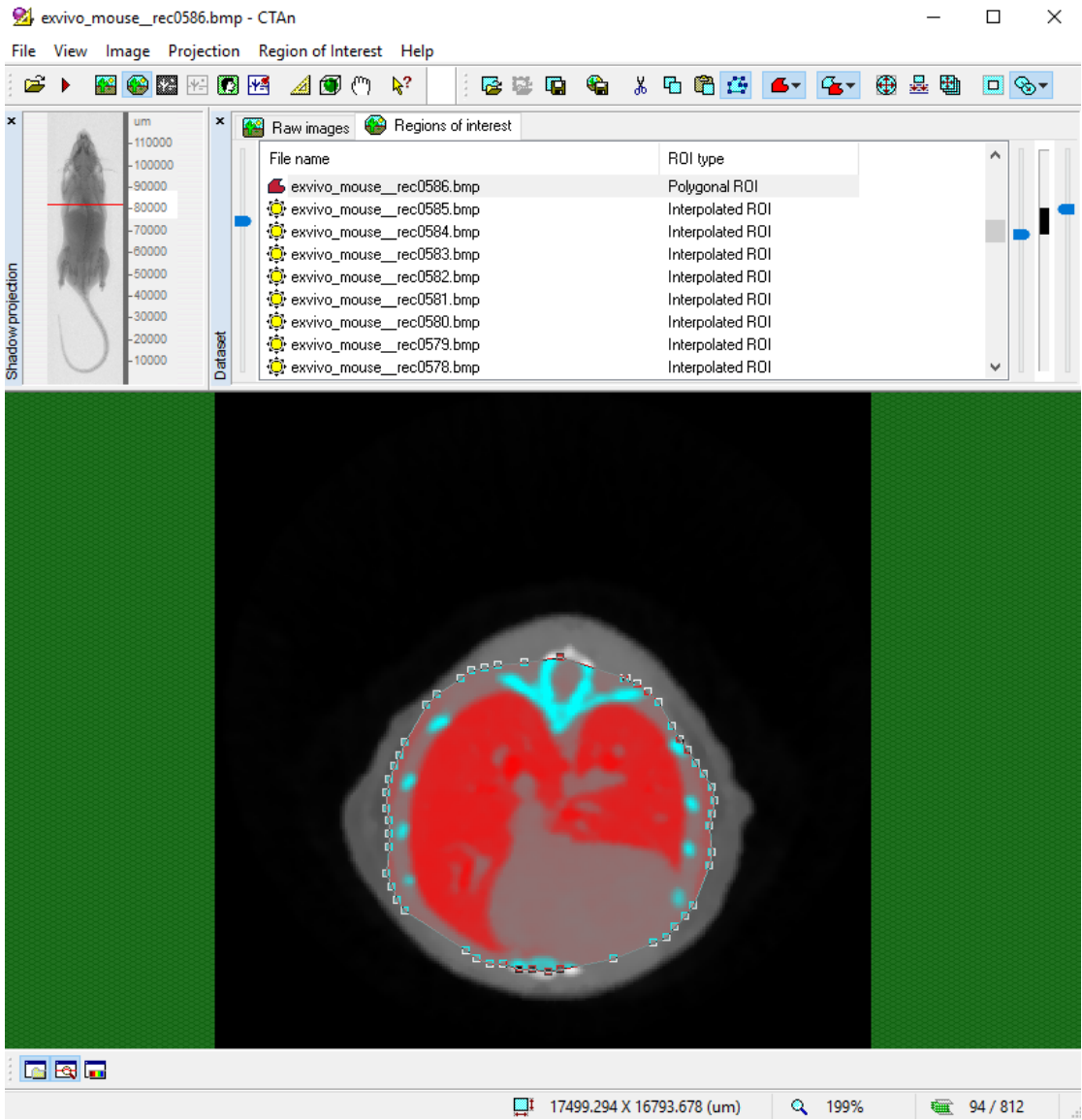
File name	ROI type
exvivo_mouse__rec0543.bmp	Interpolated ROI
exvivo_mouse__rec0542.bmp	Interpolated ROI
exvivo_mouse__rec0541.bmp	Interpolated ROI
exvivo_mouse__rec0540.bmp	Interpolated ROI
exvivo_mouse__rec0539.bmp	Interpolated ROI
exvivo_mouse__rec0538.bmp	Interpolated ROI
exvivo_mouse__rec0537.bmp	Interpolated ROI
exvivo_mouse__rec0536.bmp	Interpolated ROI
exvivo_mouse__rec0535.bmp	Interpolated ROI

Scroll to bottom of lungs and set as **Set the Bottom of Selection** by selection from the right-click menu.

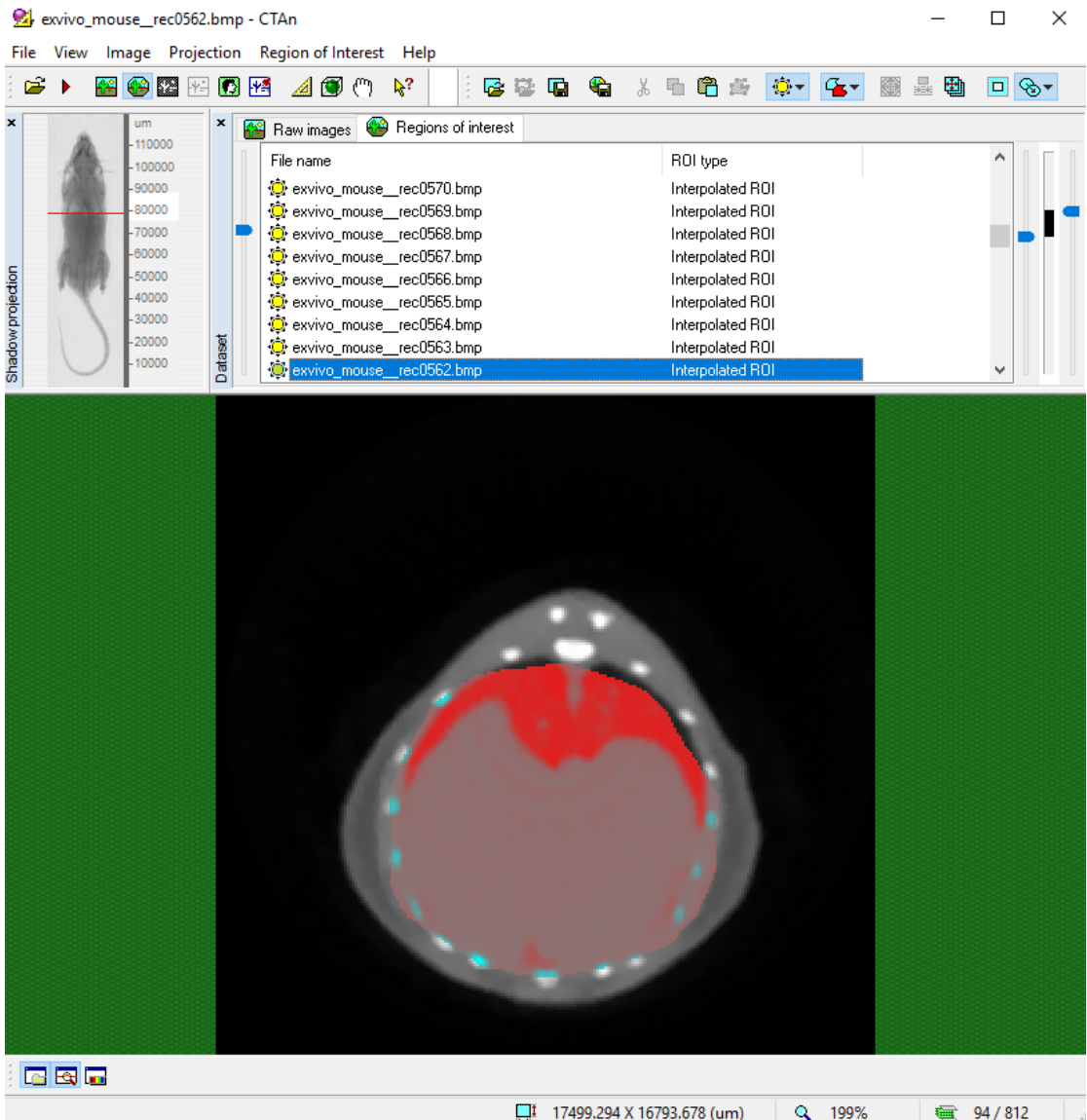


File name	ROI type
exvivo_mouse__rec0634.bmp	Interpolated ROI
exvivo_mouse__rec0633.bmp	Interpolated ROI
exvivo_mouse__rec0632.bmp	Interpolated ROI
exvivo_mouse__rec0631.bmp	Interpolated ROI
exvivo_mouse__rec0630.bmp	Interpolated ROI
exvivo_mouse__rec0629.bmp	Interpolated ROI
exvivo_mouse__rec0628.bmp	Interpolated ROI
exvivo_mouse__rec0627.bmp	Interpolated ROI
exvivo mouse rec0626.bmp	Interpolated ROI

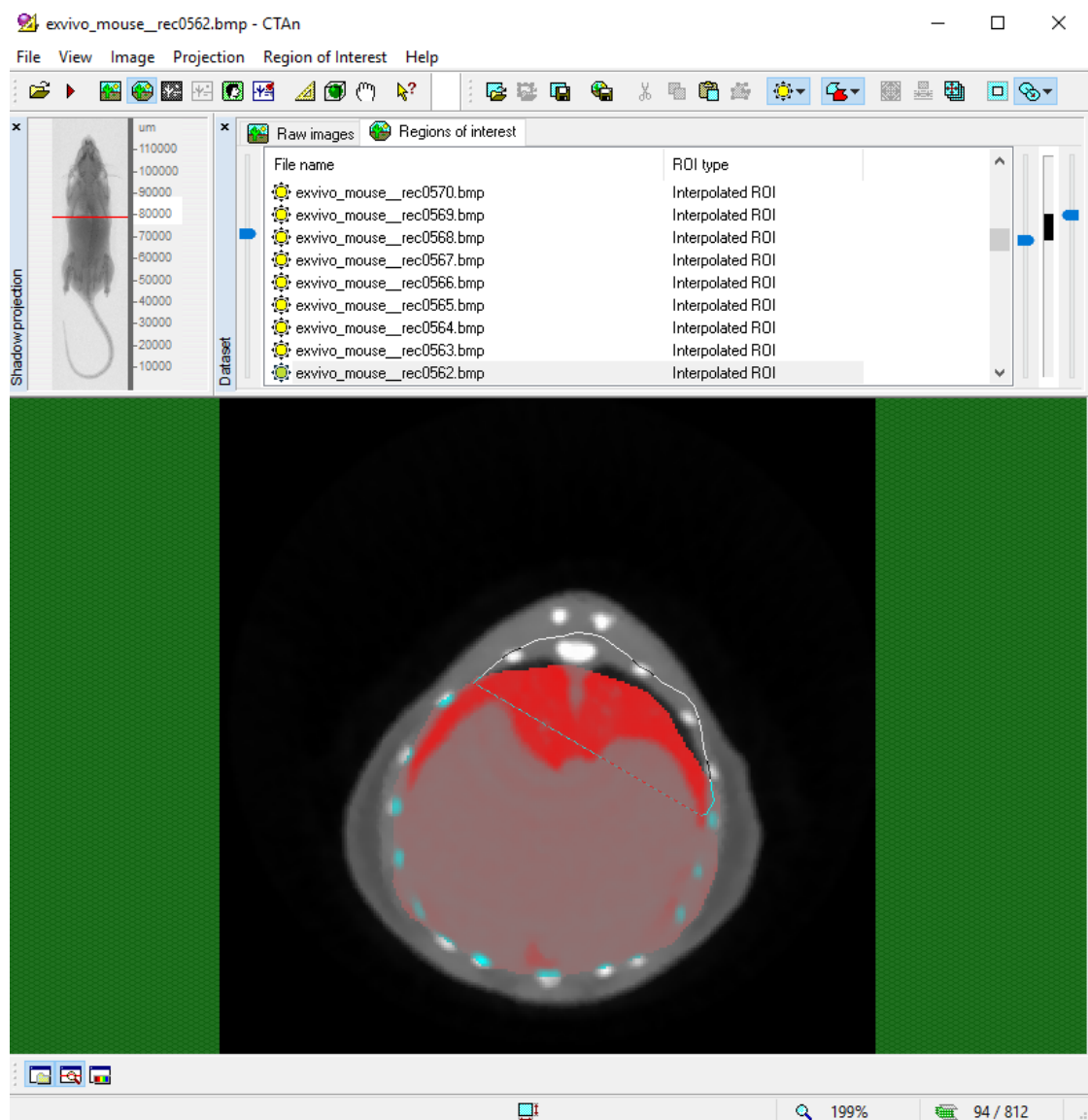
Similarly, scroll to the top of lungs and set as **Set the Top of Selection**.



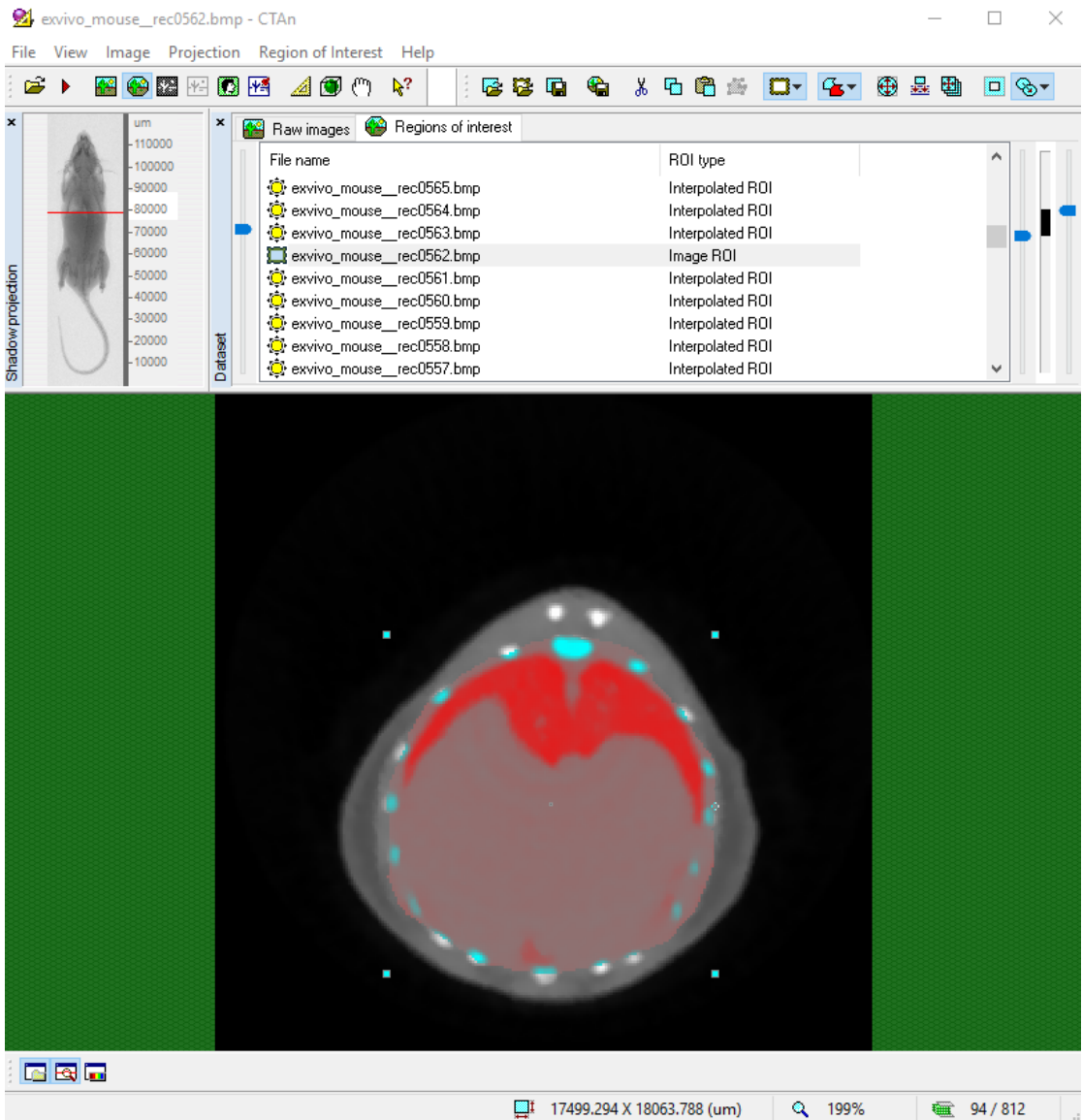
Using freehand, left click mouse and hold to draw an area encompassing the lungs.

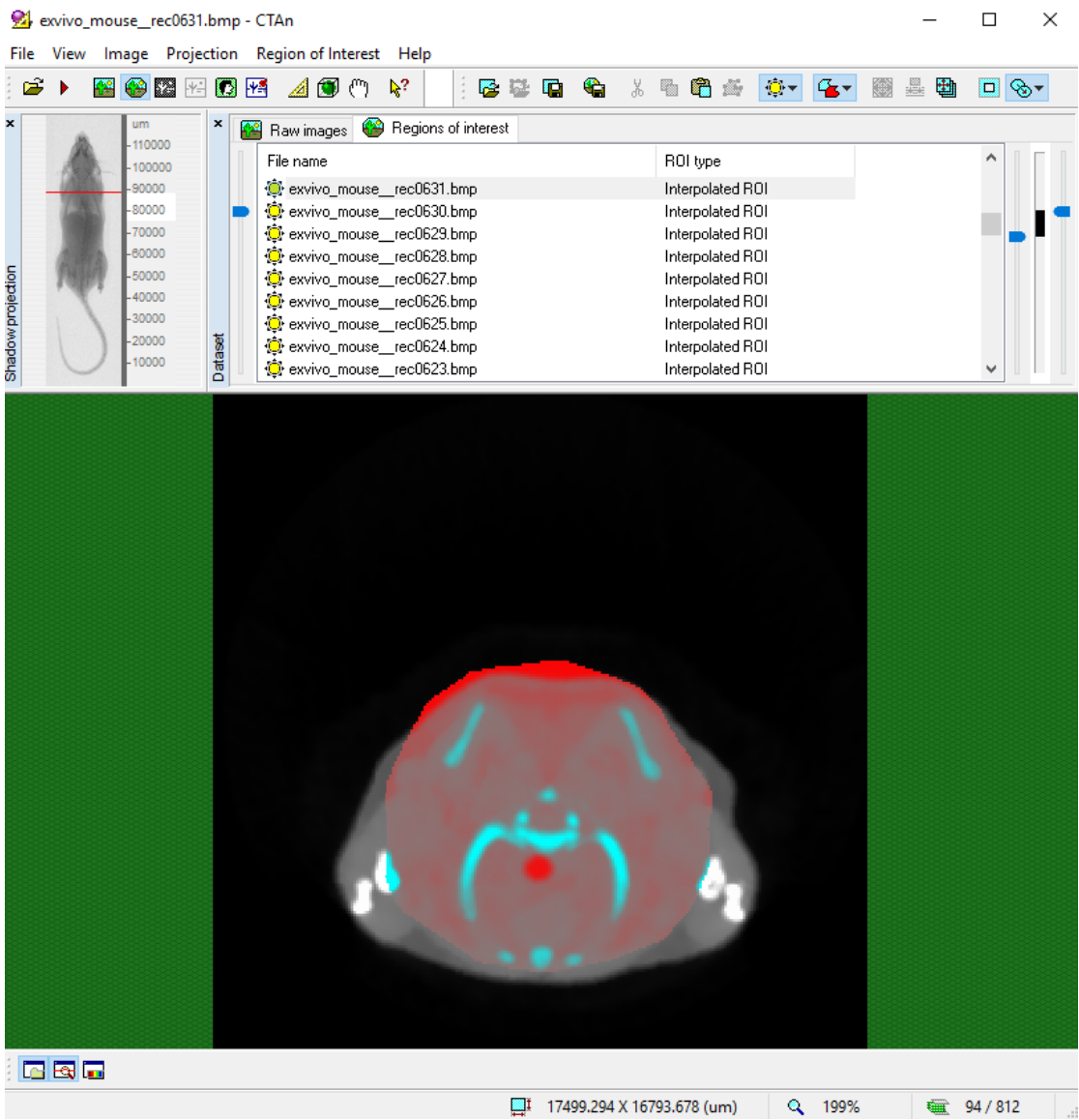


Scroll through the slices to identify a slice with a significant mismatch between interpolated ROI and lung region.

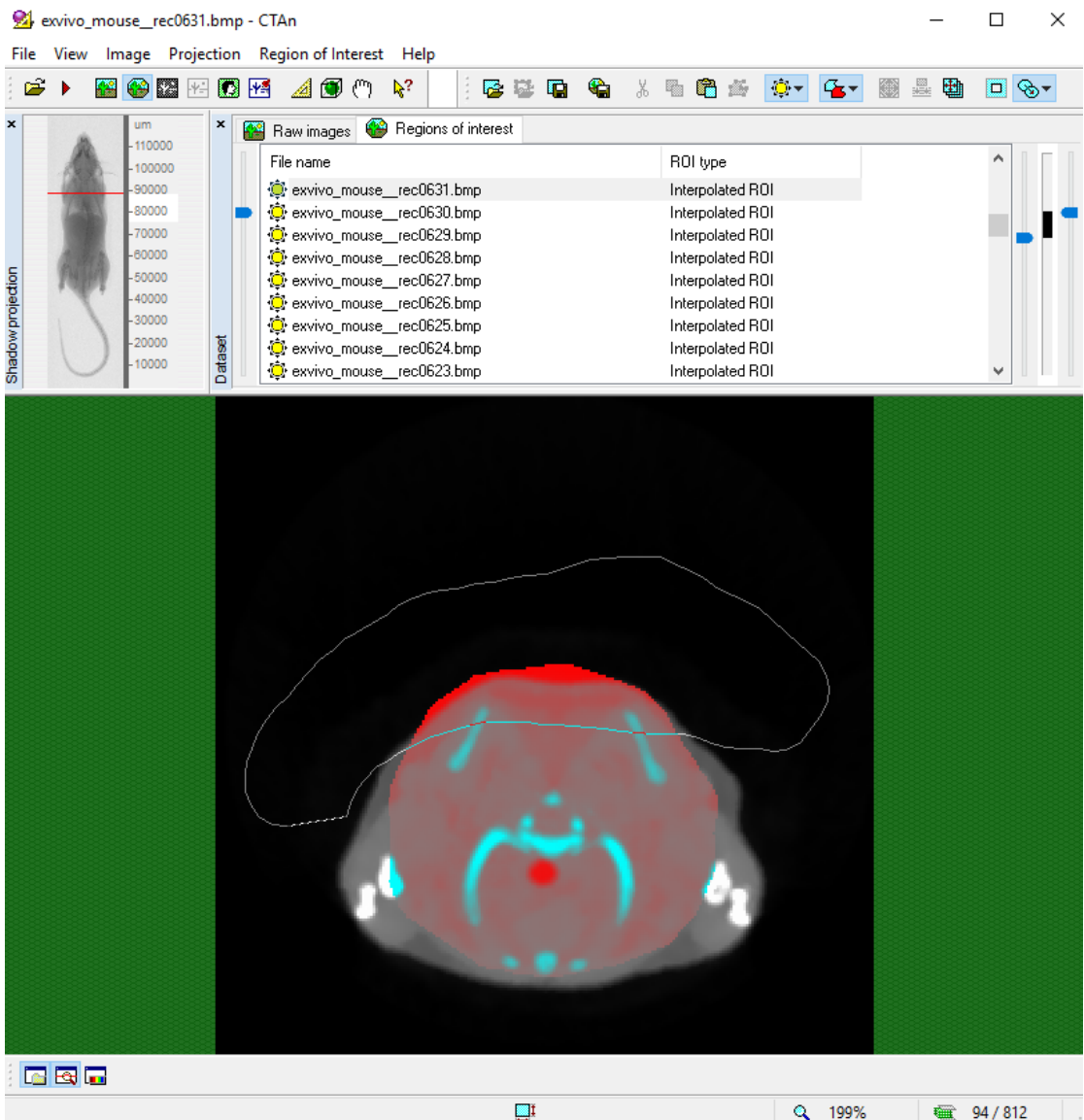


Modify the interpolated ROI for the slice by pressing Shift and holding on to the right mouse click. Add a small region to include the part of the lungs not covered by the original interpolated ROI.

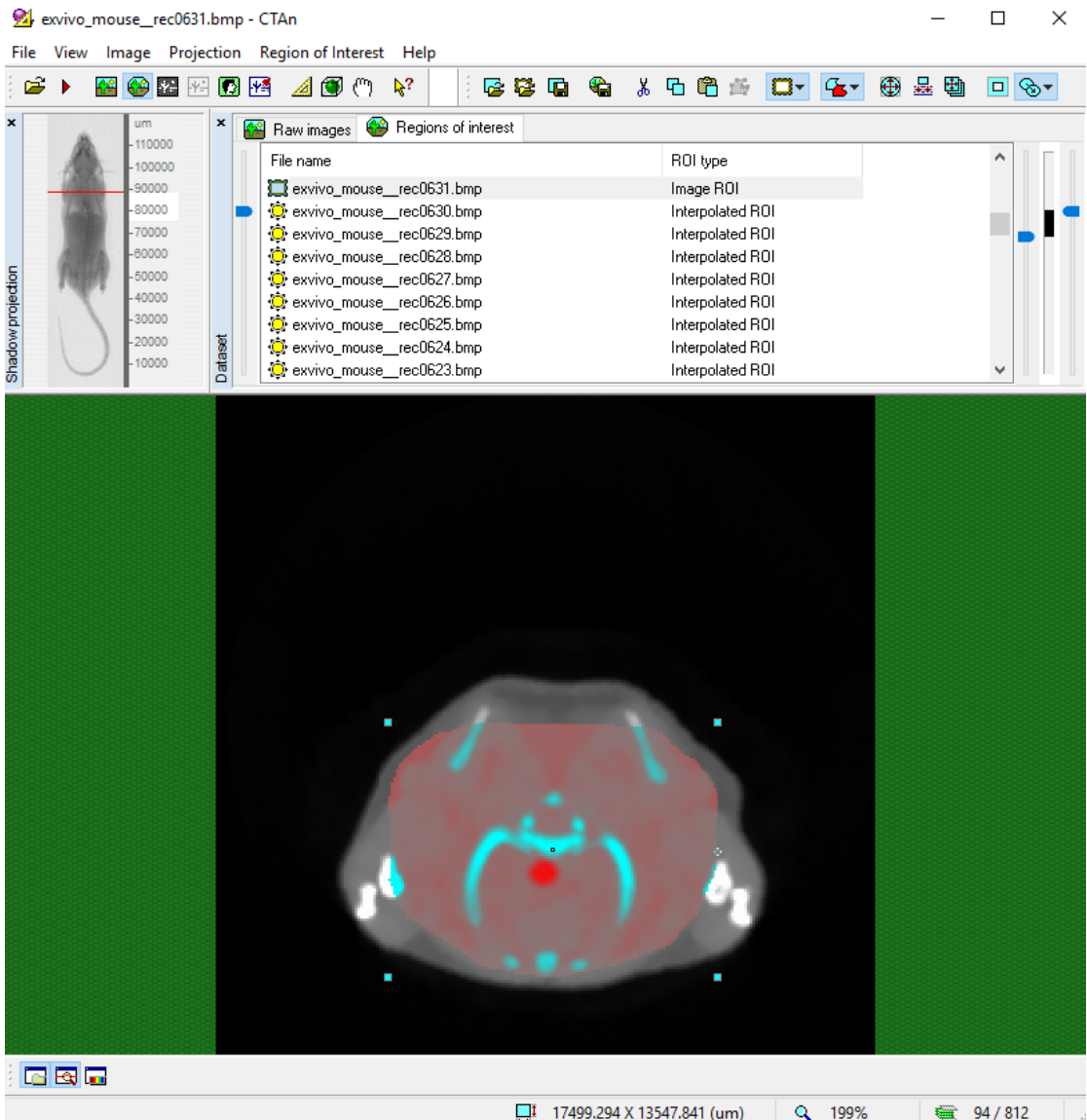




Scroll through the slices and find a slice in which the interpolated ROI protrudes out from mouse body. By pressing on to Ctrl and holding the right mouse button, draw a small region to be deducted from the original interpolated ROI.



By pressing on to Ctrl and holding the right mouse button, draw a small region to be deducted from the original interpolated ROI.



The corrected ROI after deduction of the excess part of the original shape.

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