RT_Image v0.2β User's Guide

RT_Image is a three-dimensional image display and analysis suite developed in IDL (ITT, Boulder, CO). It offers a range of flexible tools for the visualization and quantitation of DICOM datasets encompassing a variety of medical imaging modalities.

Compatibility
Operating system: Windows 98, 2000, Me, XP
Processor: Pentium 1 GHz or faster
RAM: 128 MB free (larger amounts, up to 2 GB, are preferable when dealing with large datasets)
Software: IDL version 6.0 or later

Features

Image format: DICOM

Image display:
- Multi-plane viewing
- Oblique slicing/projection
- Interactive window/levelling
- Lookup table manipulation

Image processing:
- Fusion
- Filter
    - Average
    - Median
    - Sobel
    - Gaussian
    - Difference of Gaussians
    - Add noise
- Mask
- Registration
- Resample

ROI analysis:
- Definition
    - Rectangular
    - Elliptical
    - Freehand
    - Intensity contour
    - Region grow
    - Gradient find
    - Grouping into composite ROIs
    - Split into component ROIs
    - Input from ROI files
    - Import from DICOM RT structure sets
- Manipulation
    - Placement
    - Edit points
        - Vertex edit
        - Resample
        - Smooth
        - Adjust vertices according to image
        - Morphologic operators
    - Edit geometry
- Analyze pixel statistics
- Export to existing DICOM RT structure set

Menus

- **File**

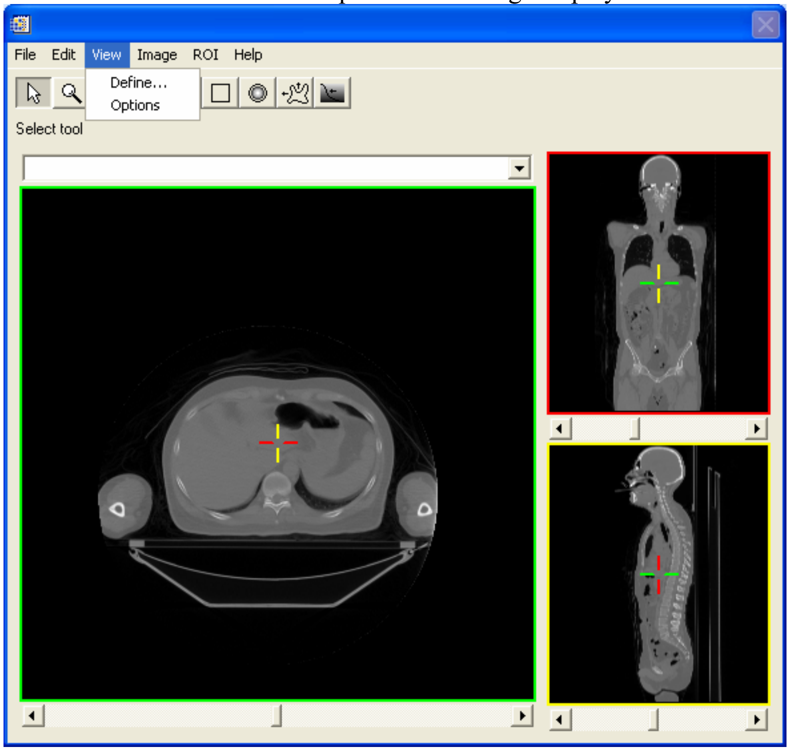
  The file menu controls the reading of image data.

- Open…: Shows the user the DCM image browser, in which one or more DICOM image series may be selected for loading. (p. 9)
- Close: Closes the currently selected image dataset.
- Close multiple: Allows the user to select multiple image datasets to close.
- Quit: Ends the current RT_Image session. All unsaved data will be lost.

- **Edit**
  The edit menu allows the user to undo the last action and the cutting, copying, and pasting of defined ROIs.

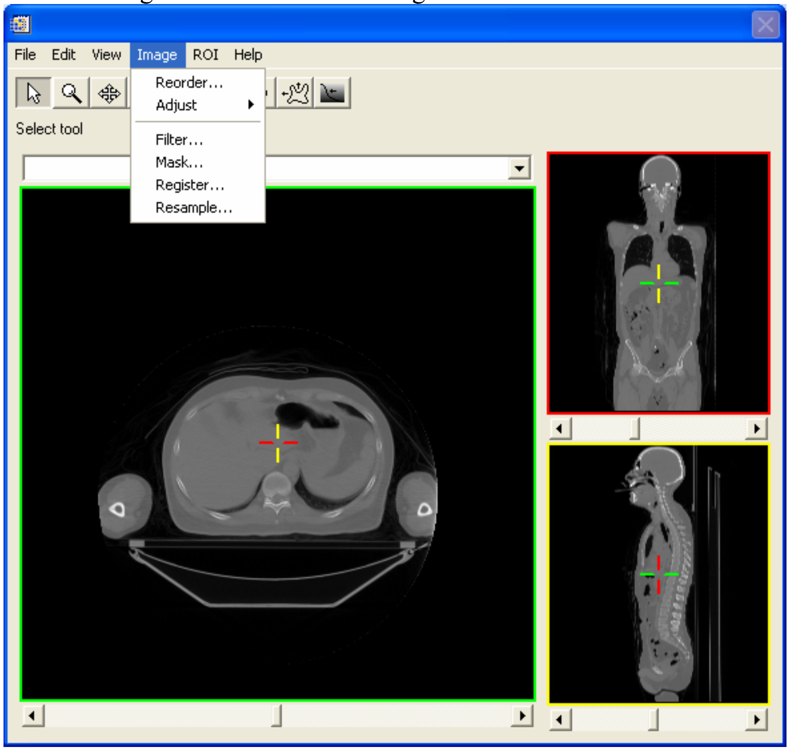
- Undo: Returns the program to its state prior to the last action. Note that undo does not work sequentially, ie the user cannot step backwards through multiple actions.
- Cut: Deletes the currently selected ROI or ROIs and saves them to the clipboard for subsequent pasting.
- Copy: Copies the currently selected ROI or ROIs to the clipboard for subsequent pasting.
- Paste: Places a copy of the ROI or ROIs on the clipboard on the currently selected image. The orientation (surface normal and axes) and center location of the ROI is adjusted to match that of the currently viewed image slice.

- **View**
  The view menu controls aspects of the image display.



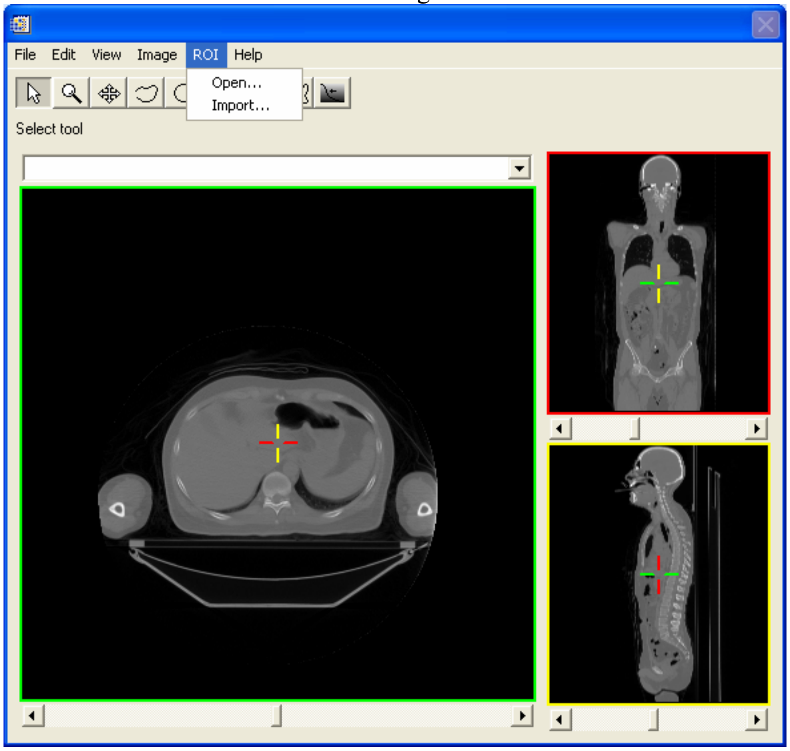
- Define…: Opens the set view window, allowing specification of the current view transformation. (p. 10)
- Options: Opens the view options window, allowing specification of several aspects of the image display. (p. 11)

- **Image**
  The image menu contains the image-associated controls.



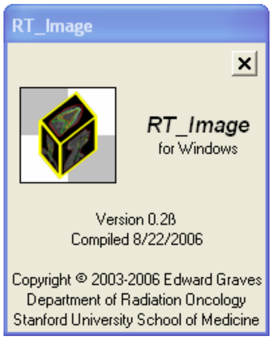
Page Break

- **ROI**
  The ROI menu controls the reading of ROI data.



- Open…: Allows the user to select one or more ROI files to load. The ROI format is specific to RT_Image. (p. 18)
- Import…: Shows the user the DCM RT browser, in which contours from a DICOM RT structure set file may be selected for loading. (p. 18)

- **Help**
  The help menu contains basic program information.



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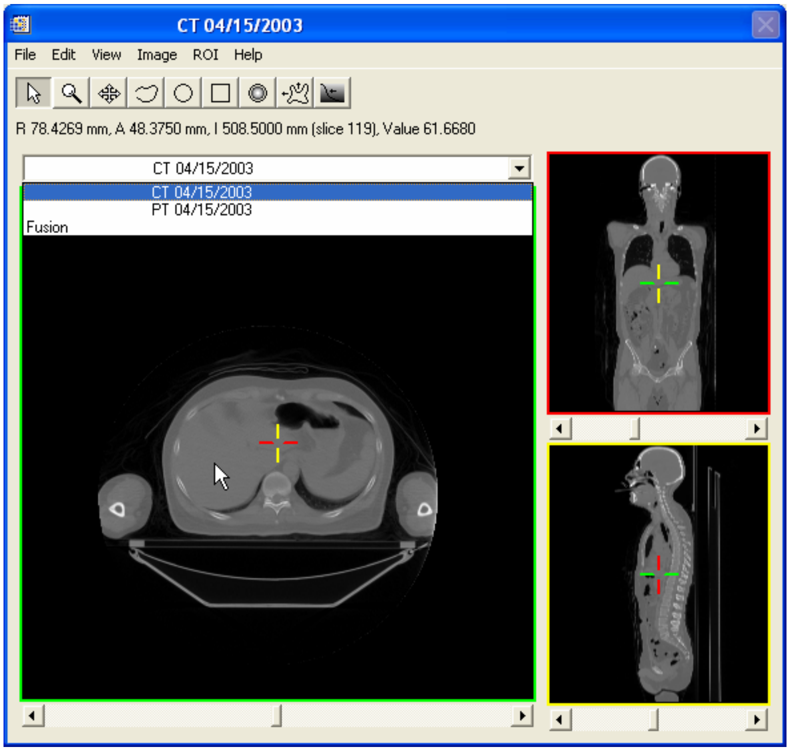
Stanford University School of Medicine

- <u>About RT_Image…</u>: Displays the program information window, containing program version and compilation date.

Controls

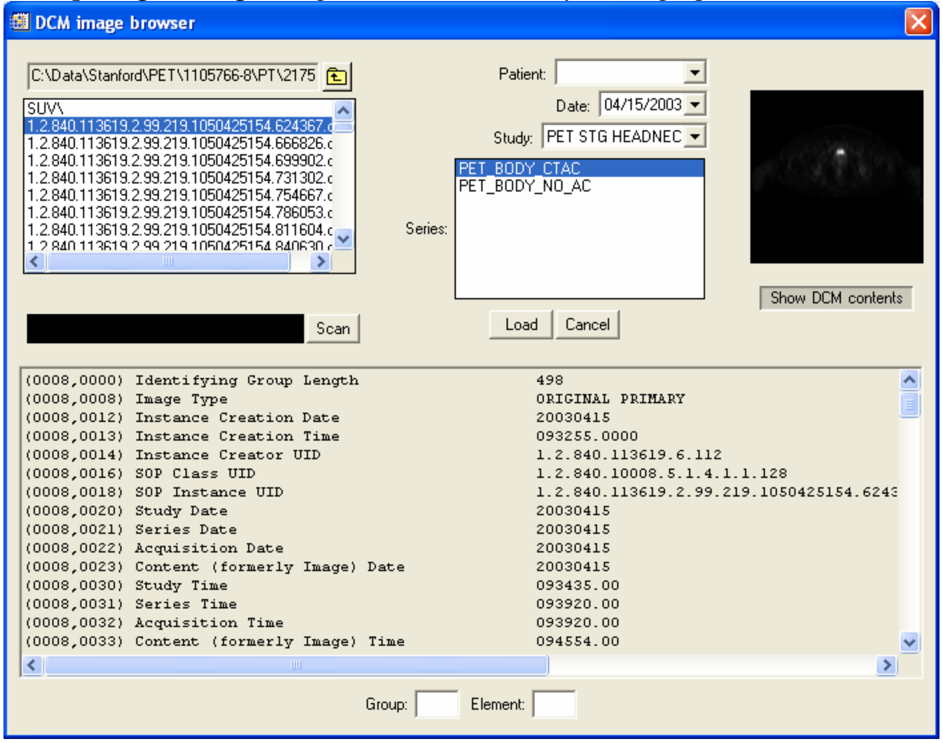


R 78.4269 mm, A 48.3750 mm, I 508.5000 mm (slice 119), Value 61.6680

- Tools: The available and currently selected tools for use are displayed below the menu bar.
  - Select: Selects ROIs and adjusts crosshair. (p. 10)
  - Zoom: Zooms the view in and out. (p. 12)
  - Pan: Translates the current view.
  - Freehand: Define freehand ROIs. (p. 16)
  - Ellipse: Define elliptical ROIs. (p. 16)
  - Rectangle: Define rectangular ROIs. (p. 16)
  - Intensity contour: Define ROIs by intensity contouring. (p. 16)
  - Region grow: Define ROIs by region growing. (p. 17)
  - Gradient finding: Define ROIs by a combination of region growing and gradient finding. (p. 17)
- Cursor information: The area underneath the toolbar displays the current location of the cursor as well as the image intensity at that point.
- Image selection droplist: The droplist immediately above the image window selects the currently active image dataset. Images are listed by patient name, modality, and date.
- Slice sliders: The sliders below each image window control the slice location shown in that window.

Images

- **Opening an image**: Image data can be loaded by clicking Open… under the File menu.



C:\Data\Stanford\PET\1105766-8\PT\2175

SUV\
1.2.840.113619.2.99.219.1050425154.624367.c
1.2.840.113619.2.99.219.1050425154.666826.c
1.2.840.113619.2.99.219.1050425154.699902.c
1.2.840.113619.2.99.219.1050425154.731302.c
1.2.840.113619.2.99.219.1050425154.754667.c
1.2.840.113619.2.99.219.1050425154.786053.c
1.2.840.113619.2.99.219.1050425154.811604.c
1.2.840.113619.2.99.219.1050425154.840630.c

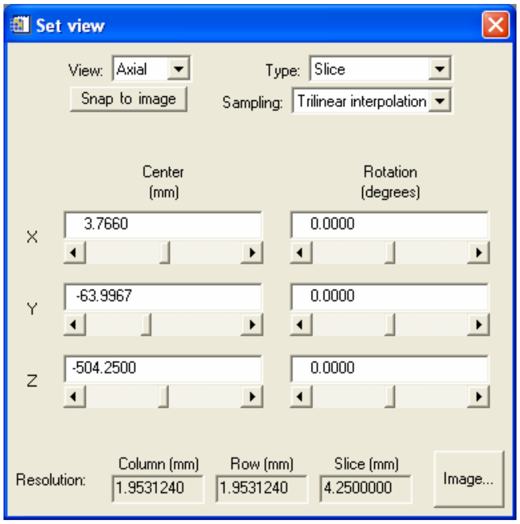
Patient:
Date: 04/15/2003
Study: PET STG HEADNEC
Series: PET_BODY_CTAC
PET_BODY_NO_AC

```
(0008,0000) Identifying Group Length              498
(0008,0008) Image Type                            ORIGINAL PRIMARY
(0008,0012) Instance Creation Date                20030415
(0008,0013) Instance Creation Time                093255.0000
(0008,0014) Instance Creator UID                  1.2.840.113619.6.112
(0008,0016) SOP Class UID                         1.2.840.10008.5.1.4.1.1.128
(0008,0018) SOP Instance UID                      1.2.840.113619.2.99.219.1050425154.6243
(0008,0020) Study Date                            20030415
(0008,0021) Series Date                           20030415
(0008,0022) Acquisition Date                      20030415
(0008,0023) Content (formerly Image) Date         20030415
(0008,0030) Study Time                            093435.00
(0008,0031) Series Time                           093920.00
(0008,0032) Acquisition Time                      093920.00
(0008,0033) Content (formerly Image) Time         094554.00
```

Group:
Element:

- Directory contents list: This list displays the contents of the currently selected directory. When a directory is opened, it is scanned for usable DICOM files. This may take up to several minutes for directories containing many (1000+) DICOM files. The results of this scan are archived so that subsequent accesses of the directory will not require a full re-scan.
- Patient, date, study, and series lists: Once a directory is scanned for DICOM files, the data present is compiled by patient, date, study, and series. This information is presented in these lists. The lists are hierarchical: selecting a patient will show the dates, studies, and series available for that patient, then selecting a date will show the studies and series for that date, and so on.
- Load button: To load data, select the desired one or more **SERIES** from the series list and click load. Note: selecting files from the directory contents list and clicking load will **NOT** open data.
- Preview window: The preview window displays the contents of the selected file.
- Show DCM contents button: To view the DICOM tags contained in a given file, select the file from the directory contents list and click the Show DCM contents button. The window at bottom will then be displayed, showing a list of the tags present in the DICOM file sorted by group and element number. The list can be restricted to specific group and/or element numbers by filling in the appropriate fields at the bottom of the window.

- **Viewing an image**: Image data can be loaded by clicking Open… under the File menu.



View: Axial

Type: Slice

Sampling: Trilinear interpolation

	Center (mm)	Rotation (degrees)
X	3.7660	0.0000
Y	-63.9967	0.0000
Z	-504.2500	0.0000

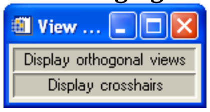
	Column (mm)	Row (mm)	Slice (mm)
Resolution:	1.9531240	1.9531240	4.2500000

- <u>Image windows</u>: The image display windows are color coded. The red and yellow windows at right always show coronal and sagittal views of the currently selected dataset. The view of the primary green window may be adjusted using the define view window under the View menu.
- <u>Crosshairs</u>: The crosshairs shown on each image are color coded to match the image windows, showing the orientation of the slice shown in the other two windows. The select tool may be used to grab the crosshair in any window and adjust its location. Upon releasing the left mouse button after dragging the crosshair, the other two windows will be updated with the corresponding image slice through the new crosshair location.

<u>Set view window</u>

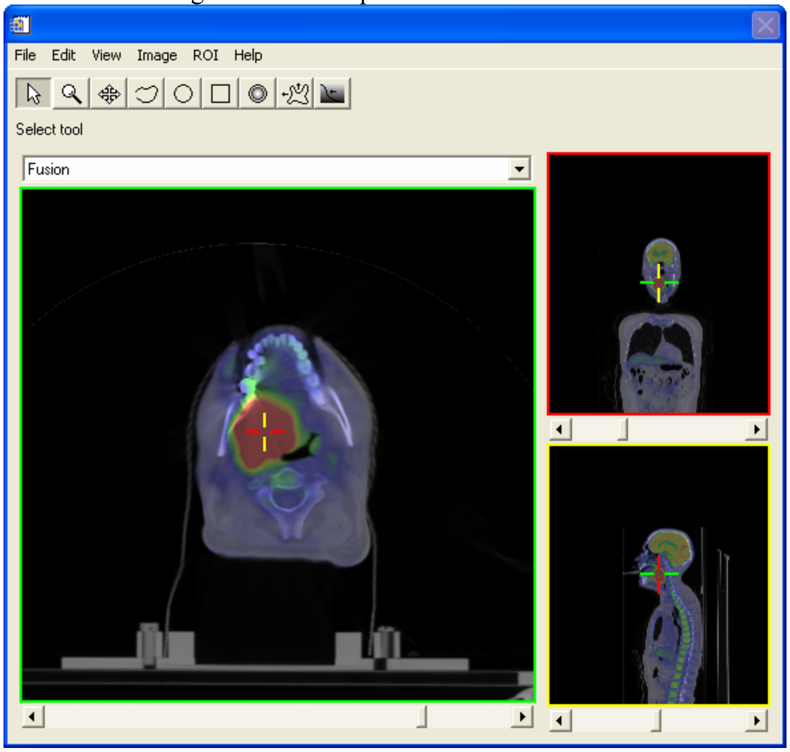
- <u>Center and rotation sliders</u>: These controls specify the physical center location and rotation of the image plane shown in the primary, green image window. Any arbitrary oblique view may be specified by adjusting these sliders.
- <u>View droplist</u>: Preset axial, coronal, and sagittal views may be selected for the primary window using this droplist.
- <u>Snap to image button</u>: The view of the primary window may be fixed to match that of a loaded image dataset by clicking this button and selecting the desired image.
- <u>Type droplist</u>: The type of image shown in the primary window is selected using this control. The choices are:
    - <u>Slice</u>: A section is taken from the selected image dataset.
    - <u>MIP</u>: A maximum intensity projection at the specified direction (according to the rotation sliders) is displayed.
    - <u>Surface rendering</u>: The surface corresponding to the current display intensity minimum is rendered according to the current view transformation.
    - <u>Volume rendering</u>: A volume projection of the current image is rendered. With this option selected, the Set RGBO button becomes available to specify the rendering color and opacity lookup tables.
- <u>Sampling droplist</u>: When the selected type is Slice, the selection of the sampling droplist determines the type of interpolation used to generate the displayed image. The choices are nearest neighbor (no interpolation), and trilinear interpolation.
- <u>Resolution fields</u>: These values specify the physical spatial resolution of the currently displayed image. Zooming in and out will adjust these values accordingly. The resolution of the view may be fixed to that of a loaded image by clicking the Image… button and selecting the desired image.

- **Changing view options**: Options for the current view can be accessed by selecting Options from the View menu.



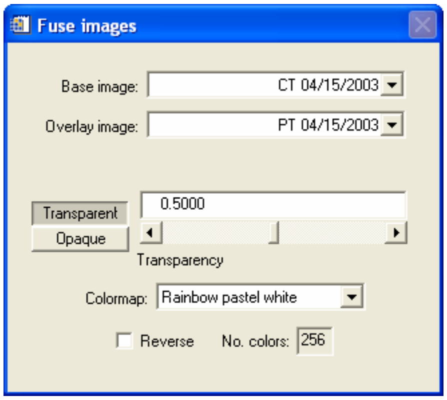
  - Display orthogonal views button: This option allows the user to show or remove the coronal and sagittal secondary view windows from the program window.
  - Display crosshairs: This option allows the user to enable or disable display of the crosshair in each of the three image windows.

- **Viewing a fused image**: When two or more images are open, the user may view an fusion of two images by selecting Fusion from the Image selection droplist.



  - Base image droplist: This control selects the image dataset to be used as the underlying foundation for the fusion.
  - Overlay image droplist: This control selects the image to be superimposed on top of the base image.
  - Transparent, Opaque buttons: These select whether the overlay image is superimposed on the base image in an opaque (overlay colors completely obscure the base image) or transparent (one can partially see the base image through the overlay) manner.
  - Transparency slider: The value selected in this control determines the transparency of the overlay when the Transparent option is selected.
  - Colormap droplist: The colormap used for the overlay image is selected using this droplist.
  - Reverse button: Allows the user to reverse the order of the selected colormap.
  - No. colors field: Specifies the number of colors to be used in the selected colormap.

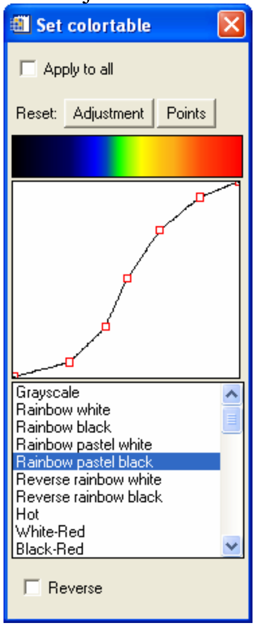
  - Adjust Min/Max window: When viewing a fused image, the Adjust Min/Max window has an extra option specifying whether the display range of the base or overlay is being adjusted.



Base image: CT 04/15/2003
Overlay image: PT 04/15/2003
0.5000
Transparency
Colormap: Rainbow pastel white
☐ Reverse
No. colors: 256

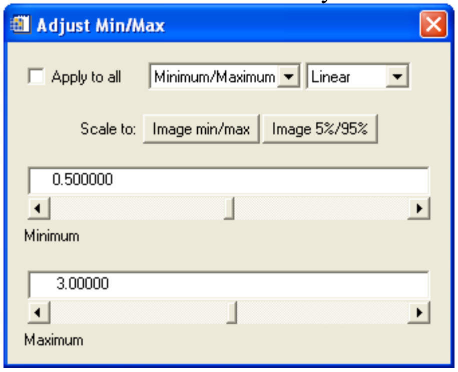
- **Magnifying an image**: The zoom tool may be used to zoom any of the three image windows in and out. Left clicking in a window with the zoom tool selected will cause the magnification of that window to increase by a factor of 2. Left clicking while holding down the ALT key will cause the magnification of the window the decrease by a factor of 2. Every magnification/demagnification event shifts the center and crosshair location of each window to the location where the user clicked.

- **Setting an image's color table**: The lookup table of the currently selected image can be specified and manipulated by selecting Adjust→Color table from the Image menu.



  - Apply to all button: When this option is selected, changes to display settings made in the Set colortable window will be applied to all open images.
  - Image intensity mapping curve: The curve underneath the colortable displays graphically how colors in the color table are assigned to image intensity values between the display minimum and maximum. Adjustment points (red boxes) allow the user to modify this curve. Left clicking and dragging an adjustment point will shift the shape of the curve. Right clicking on the curve will create a new adjustment point.
  - Reset Adjustment button: Clicking this button returns the image intensity mapping curve to a straight line.
  - Reset Points button: Clicking this button returns the adjustment points of the image intensity mapping curve to the initial three at 0, 0.5, and 1.
  - Color table droplist: The list at bottom selects the color table of the current image. A variety of predefined color tables are provided. A color table consists of a 256 element list of colors. When an image is displayed, it is first scaled so that values below or equal to the image display minimum setting become 0, values above or equal to the image display minimum setting become 255, and values in between are scaled linearly or logarithmically into integer values. After scaling, the pixel's intensity (0 to 255) is used to "look up" a color in the table, which is used for that pixel. This scaling is for display only, and does not affect the actual pixel intensities or internal representation in the image.
  - Reverse button: Selecting this option will reverse the direction of the currently selected color table.

- **Setting an image's display range**: The display range of the currently selected image, which specifies the upper and lower image intensities on the currently selected color table, can be adjusted by selecting Adjust→Min/Max… from the Image menu.

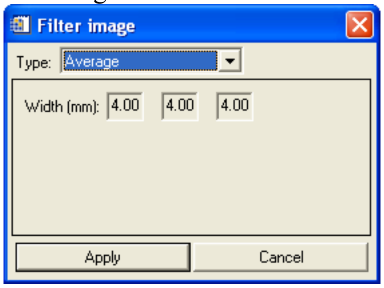


0.500000
Minimum

3.00000
Maximum

  - Apply to all button: When this option is selected, changes to display settings made in the Adjust Min/Max window will be applied to all open images.
  - Minimum/Maximum, Window/Level droplist: The droplist immediately to the left of the Apply to all button selects whether the image display range is specified by the minimum (black) and maximum (white) image intensities, or by the image window (maximum-minimum) and image level (center intensity).
  - Linear, Logarithmic droplist: The droplist to the left of the Minimum/Maximum, Window/Level droplist selects the type of mapping used to display image intensities.
  - Scale to buttons: These buttons allow specification of an image's display parameters relative to its pixel intensities. Scale to Image min/max sets the display minimum and maximum to the minimum and maximum intensities of the image. Scale to 5%/95% sets the display minimum and maximum to the 5th and 95th percentiles of the image's histogram. If the apply to all button is checked, the display parameters of all images are set to their minimum/maximum or 5th and 95th percentile.
  - Minimum/Maximum, Window/Level sliders: The sliders at the bottom of the window specify explicit values for the image display parameters.

- **Filtering an image**: The currently selected image may be filtered using one of several operators by selecting Filter… under the Image menu.

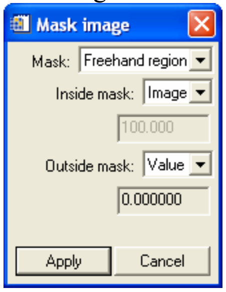


Type: Average

Width (mm): 4.00 4.00 4.00

- Type droplist: The type of filter to be applied to the currently selected image is selected using this control. The available options are:
    - Average: A boxcar smoothing filter of the specified physical width.
    - Median: A median filter of the specified dimensions.
    - Sobel: The Sobel gradient approximation of an image.
    - Gaussian: Convolution with a Gaussian of the specified dimensions and physical size.
    - Difference of Gaussians: Convolution with the difference of two Gaussians of the specified dimensions and physical sizes.
    - Add noise: Adds noise of the specified type and parameters to the image.

- **Masking an image**: Regions of the currently selected image may be set to a constant fixed value by selecting Mask… under the Image menu.



Mask: Freehand region

Inside mask: Image

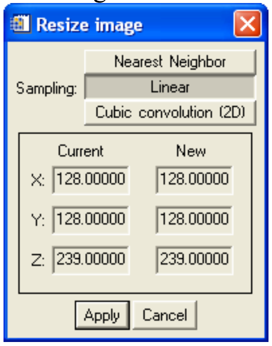
100.000

Outside mask: Value

0.000000

- Mask droplist: This control selects the ROI to be used as a basis for masking the image.
- Inside mask options: The user can specify how image regions inside the ROI will be processed using these controls. Options under the droplist are Image (the image inside the ROI will be unaffected) or Value (the image regions inside the ROI will be replaced by a fixed value). When Value is selected, the field underneath the droplist allow specification of the inside value to be used.
- Outside mask options: Using these controls, the user can specify how image regions outside the ROI will be processed in a manner analogous to that described above.

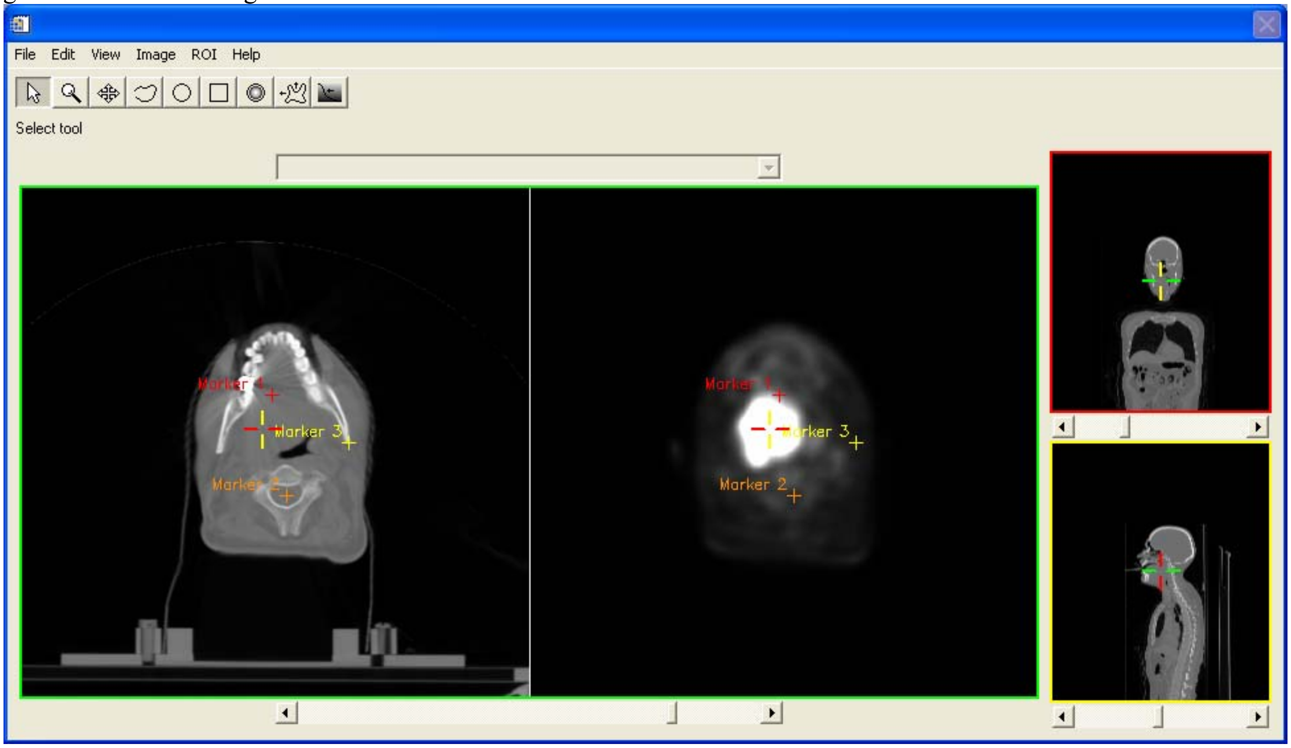
- **Resampling an image**: The currently selected image may be resampled to new dimensions by selecting Resample… under the Image menu.

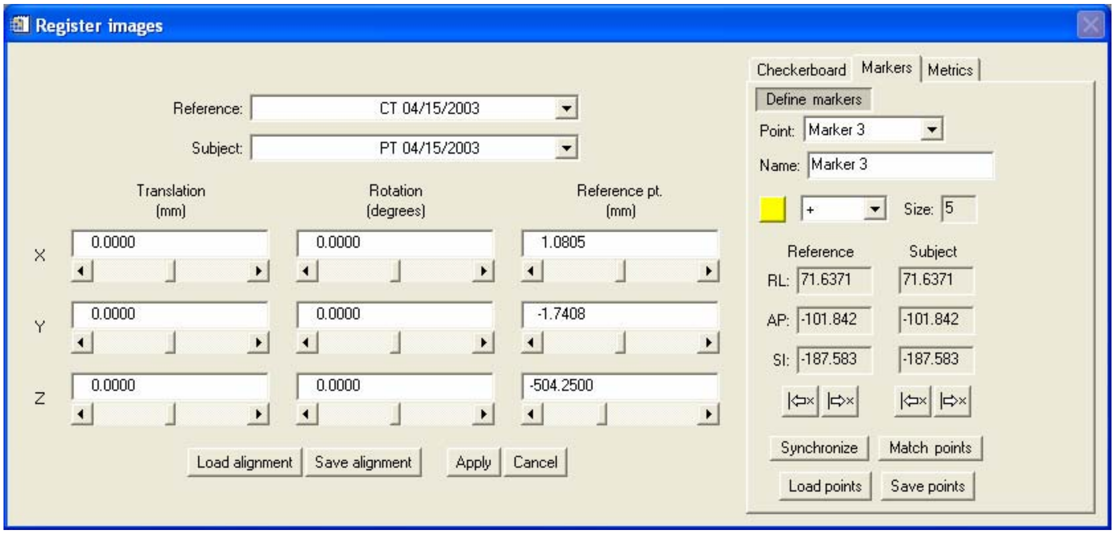


	Current	New
X:	128.00000	128.00000
Y:	128.00000	128.00000
Z:	239.00000	239.00000

- Sampling buttons: This group of buttons selects the type of interpolation to be used when resampling the image.
- Current dimensions fields: The dimensions of the currently selected image are shown here for reference.
- New dimensions fields: The user can enter new dimensions for the currently selected image in these fields. Upon clicking apply, the image will be resampled using the specified interpolation type to have the entered dimensions.

- **Registering two images**: Images may be brought into geometric alignment using a rigid body transformation by selecting Register… under the Image menu.





Reference: CT 04/15/2003

Subject: PT 04/15/2003

	Translation (mm)	Rotation (degrees)	Reference pt. (mm)
X	0.0000	0.0000	1.0805
Y	0.0000	0.0000	-1.7408
Z	0.0000	0.0000	-504.2500

Point: Marker 3

Name: Marker 3

+ Size: 5

	Reference	Subject
RL:	71.6371	71.6371
AP:	-101.842	-101.842
SI:	-187.583	-187.583

- Image display windows: When in registration mode, the main window expands so that the primary image window consists of the reference image for registration on the left, and the subject image for registration on the right. The coronal and sagittal windows display the corresponding views of the reference image for localization.

Register images window

- Reference and Subject droplists: The user can select the images to serve as the reference for registration and the subject for registration using these controls.
- Transformation sliders: The user can specify a rigid body registration transformation to be applied to the subject image using these controls. The transformation consists of a translation and a rotation along the RL, AP, and SI axes, centered at the specified reference point.
- Load, Save alignment buttons: The current alignment transformation can be saved to a ALN file, specific to RT_Image, by clicking the Save alignment button and selecting an output file. ALN files may subsequently be used to load a registration transformation by clicking the Load alignment button and selecting the desired file. Note that registration transformations created between two image datasets can be applied to any two image datasets using this mechanism.

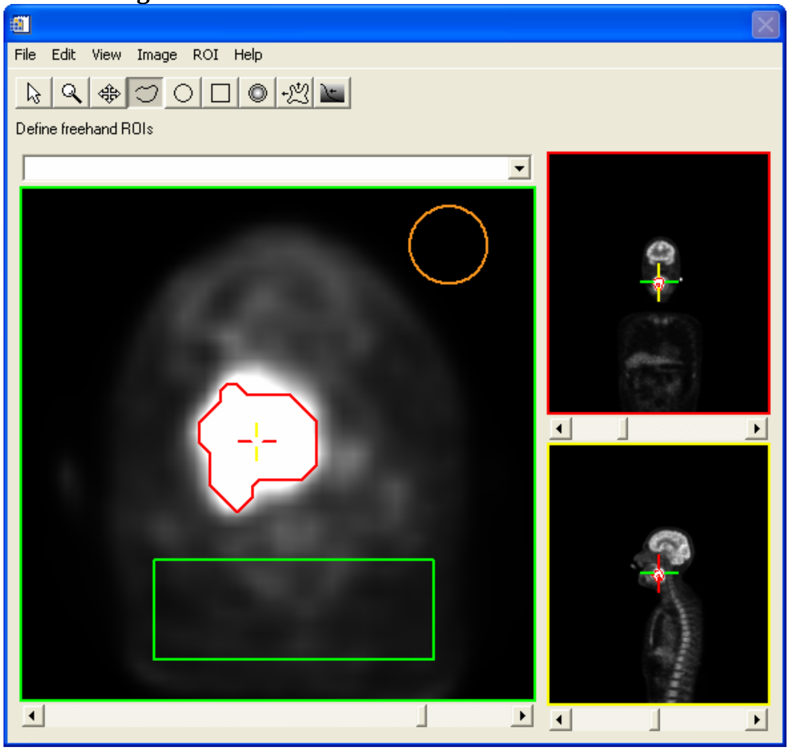
- Checkerboard options: The subject image display can be manipulated to consist of alternating patches of the reference and subject images by selecting this option. This view can be helpful for determining the goodness of registration between two images. The resolution of the checkerboard can be specified through the number of checks along the X and Y axes.
- Marker options: Registration markers can be defined and used for semi-automatic registration.
    - Define markers button: When this option is selected, the select tool can be used to create marker pairs by left clicking in the primary image window. Left clicking in a region without markers will create a new, synchronized pair of markers in the reference and subject images. Left clicking and dragging a marker will shift its location.
    - Point droplist: The user can select a specific marker pair using this droplist, and subsequently edit its properties using the controls described below.
    - Marker display options: The color, symbol, and size of a given marker pair can be specified.
    - Reference and subject location fields: The location of the marker in the reference and subject images is provided by these fields. The user can manually enter values in these boxes to explicitly set the location of each marker.
    - Shift slice, marker buttons: The buttons below the location fields allow rapid manipulation of the marker and image locations.

      |⇦× The left button moves the location of the selected marker to the currently viewed image slice.

      |⇨× The right button moves the location of the currently viewed image slice to that of the selected marker.
    - Synchronize button: When active, the currently selected marker pair will move in unison in the reference and subject images.
    - Load, Save points buttons: The current array of registration markers can be saved to a PTS file, specific to RT_Image, by clicking the Save points button and selecting an output file. PTS files may subsequently be loaded by clicking the Load points button and selecting the desired file. Note that registration points created for two image datasets can be loaded for any two image datasets using this mechanism.
    - Match points button: Once at least four registration marker pairs have been defined, they may be used to compute a registration transformation between two images by clicking the Match points button. For best results, 5-10 registration marker pairs should be defined, and should not all be coplanar. In other words, the registration points should be well-spaced across the entire image dataset.
- Metrics options: Several quantitative measures of registration can be computed.
    - Cross correlation button: Computes the cross correlation between the reference and subject image slices currently being viewed.
    - Mutual information button: Computes the normalized mutual information between reference and subject image slices currently being viewed.
- Apply button: Applies the specified registration transformation to the subject image and closes the registration interface.
- Cancel button: Returns the subject image to its original orientation and closes the registration interface.

ROIs

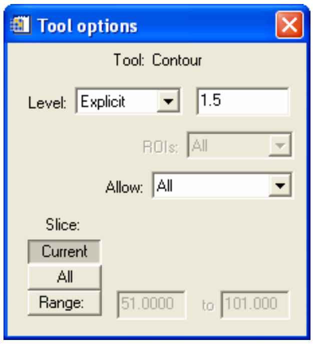
- **Defining ROIs**



All ROI definition should be performed in the primary, green image window.

- <u>Rectangle</u>: When the rectangle tool is selected, left clicking and dragging will draw a rectangular ROI. When finished drawing the rectangle, release the left button to create the ROI. Holding SHIFT while dragging out a rectangular ROI will force the shape to be square.
- <u>Ellipse</u>: When the ellipse tool is selected, left clicking and dragging will draw a elliptical ROI. When finished drawing the ellipse, release the left button to create the ROI. Holding SHIFT while dragging out a elliptical ROI will force the shape to be circular.
- <u>Freehand</u>: When the freehand tool is selected, left clicking will define a single vertex of the ROI. Subsequent clicking will define additional vertices that will be connected in order to produce a curve. The user may left click and hold to draw out curves instead of clicking individual points. When the region has been defined, right click to close the curve and create an ROI.

- <u>Composite</u>: Multiple ROIs can be grouped into a single composite ROI by selecting them and clicking Group button in the ROI list window. A composite ROI can subsequently be split into its component ROIs by clicking the Split button in the ROI list window.



Tool: Contour

Level: Explicit 1.5

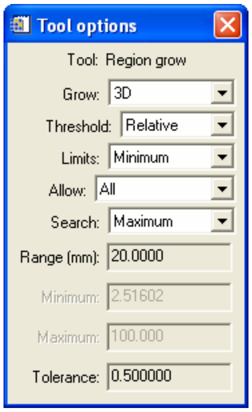
ROIs: All

Allow: All

Slice:
Current
All
Range: 51.0000 to 101.000

<u>Intensity contour</u>: Double clicking on the intensity contour tool will show the Contour options window. Intensity contouring defines ROIs by identifying curves along which the image has a constant intensity level.

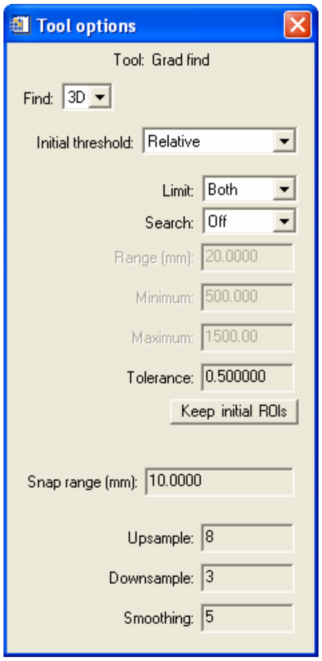
- <u>Level droplist</u>: This control specifies whether the level for which contours will be created is explicit (specified by the user in the field at right) or obtained from the intensity at the point on which the user clicks to initiate contouring.
- <u>ROIs droplist</u>: When the contour level is obtained from the point on which the user clicks, the user may choose to keep either all contours generated for this level (All), or only the contour that passes through the point that was clicked using this control (From cursor).
- <u>Allow droplist</u>: The user may confine the region over which contouring will be performed by selecting an ROI from the Allow droplist. When All is selected, contouring will be performed over the entire image slice or volume.
- <u>Slice buttons</u>: Contouring can be performed on a range of slices based on the selection made in this control. The user can choose to either contour only on the current slice, on all slices within the currently selected image, or over a range of slices as specified by the physical location of the slice.



Tool: Region grow
Grow: 3D
Threshold: Relative
Limits: Minimum
Allow: All
Search: Maximum
Range (mm): 20.0000
Minimum: 2.51602
Maximum: 100.000
Tolerance: 0.500000

Region grow: Double clicking on the region grow tool will show the Region grow options window. Region growing defines ROIs through selection of a starting point, and expansion of the region to include adjacent points that meet specified intensity criteria.

- Grow droplist: Specifies whether the region to be grown should expand in two dimensions (ie, in the current slice only) or in three dimensions.
- Threshold droplist: Specifies the type of intensity criterion to be used for region growing. Choices are discrimination by either absolute intensities, by intensities relative to the starting intensity, by the intensity of the up image gradient, or by the intensity of the down image gradient.
- Limits droplist: The user can select whether to discriminate points for region growing based on a lower limit, upper limit, or both.
- Allow droplist: The user may confine the region over which regions are allowed to grow by selecting an ROI from the Allow droplist. When All is selected, region growing will be permitted to continue over the entire image volume.
- Search droplist: Instead of beginning region growing at the point on which the user clicks to initiate the process, one can alternately choose to search for a local minimum or maximum within the image. If Minimum or Maximum is selected from this droplist, this search is performed and the starting location and intensity for region growing will be the location of the found minimum or maximum instead of the actual point that was clicked on.
- Range field: When the Search option is selected, the value of this field determines the image range over which a local minimum or maximum will be identified.
- Minimum, Maximum field: These fields specify the intensities that are the lower and upper limits of the region growing criteria. When the Threshold selection is Absolute, the user may enter explicit values in these fields. When Relative is selected in the Threshold droplist, these values will not be editable and will denote the limits determined from the image using the specified tolerance.
- Tolerance field: When the Threshold selection is Relative, the Tolerance entered in this field denotes the range of intensities relative to the starting intensity that will be included for region growing. For example, if the starting pixel intensity is 100 and the tolerance is set at 0.5, the lower intensity limit for region growing will be 50 and the upper limit will be 150.



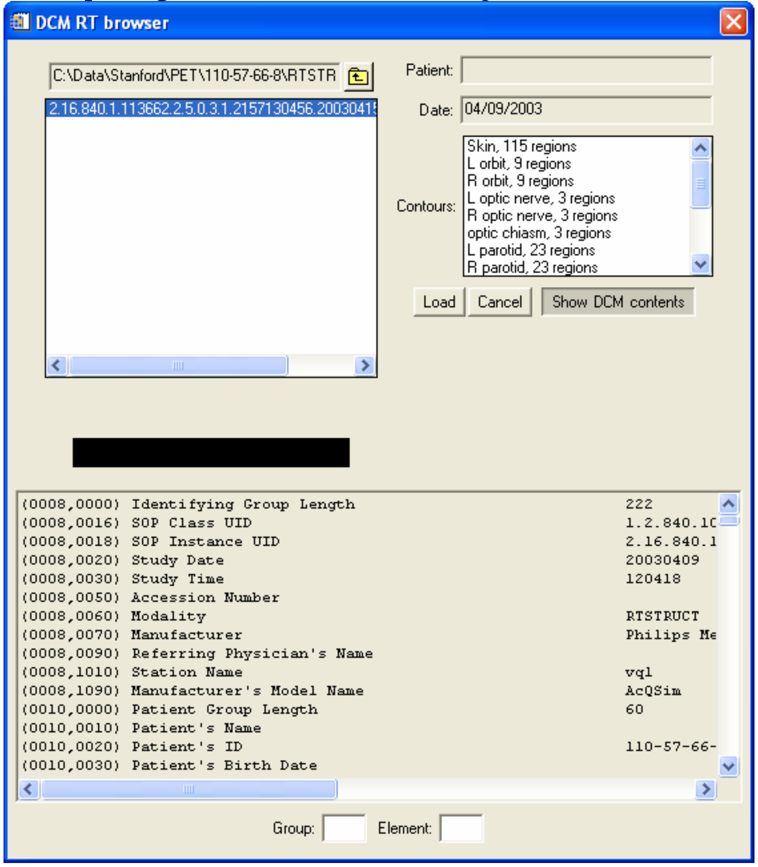
Tool: Grad find
Find: 3D
Initial threshold: Relative
Limit: Both
Search: Off
Range (mm): 20.0000
Minimum: 500.000
Maximum: 1500.00
Tolerance: 0.500000
Snap range (mm): 10.0000
Upsample: 8
Downsample: 3
Smoothing: 5

Gradient find: Double clicking on the gradient find tool will show the Gradient find options window. Gradient finding defines ROIs by initial performing region growing, then adjusting the contour vertices determined based on the gradient of the source image.

- Find droplist: Specifies whether the region to be defined should expand in two dimensions (ie, in the current slice only) or in three dimensions.
- Initial threshold options: Specifies the parameters of the region growing to be performed as an initial region definition. The meaning of these values is identical to their meaning in region growing. The ROIs created from this initial step can be kept if the Keep initial ROIs option is selected. Otherwise, they will be deleted after the subsequent gradient adjustment has been performed.
- Snap range:.This value specifies the range over which each contour vertex may be adjusted in order to shift it to a local maximum of the gradient.
- Upsample field: Prior to vertex shifting, each contour determined in the initial step will be upsampled to a higher density of vertices. The extent of upsampling is specified in this field
- Downsample field: After vertex shifting, each contour will be downsampled to a lower vertex resolution according to the value of this field.
- Smoothing field: After downsampling, the contour may be smoothed using a boxcar average over neighboring vertices by specifying the boxcar width in this field.

- **Opening an ROI**: ROI data can be loaded from an ROI file by clicking Open… under the ROI menu. The user is then prompted to select an ROI file, specific to RT_Image, from which ROI data will be loaded.

- **Importing an ROI**: ROI data can be imported from a DICOM RT structure set file by clicking Import… under the File menu.



C:\Data\Stanford\PET\110-57-66-8\RTSTR

2.16.840.1.113662.2.5.0.3.1.2157130456.2003041

Patient:

Date: 04/09/2003

Contours:
Skin, 115 regions
L orbit, 9 regions
R orbit, 9 regions
L optic nerve, 3 regions
R optic nerve, 3 regions
optic chiasm, 3 regions
L parotid, 23 regions
R parotid, 23 regions

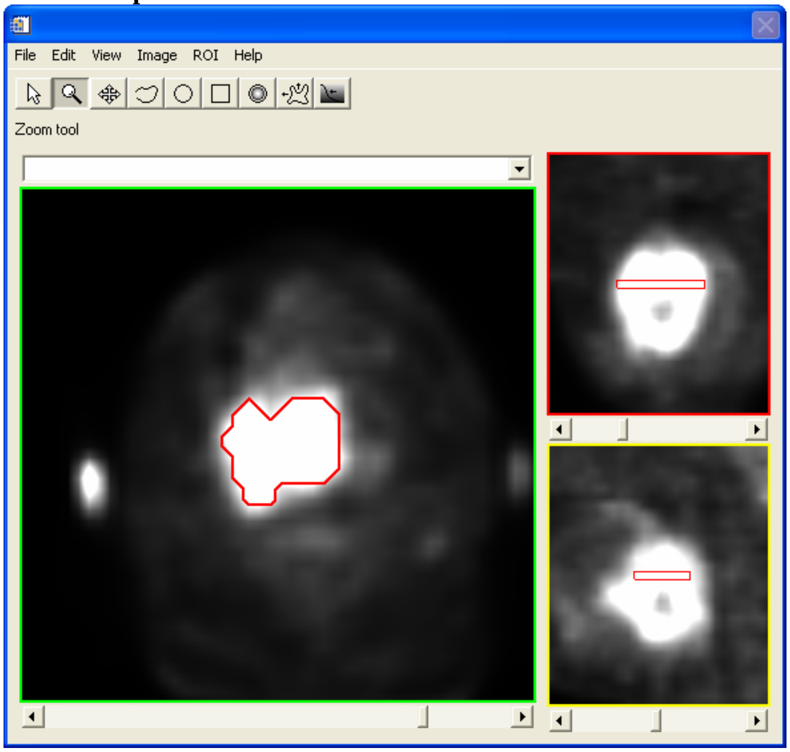
[redacted]

```
(0008,0000) Identifying Group Length                              222
(0008,0016) SOP Class UID                                         1.2.840.10
(0008,0018) SOP Instance UID                                      2.16.840.1
(0008,0020) Study Date                                            20030409
(0008,0030) Study Time                                            120418
(0008,0050) Accession Number
(0008,0060) Modality                                              RTSTRUCT
(0008,0070) Manufacturer                                          Philips Me
(0008,0090) Referring Physician's Name
(0008,1010) Station Name                                          vql
(0008,1090) Manufacturer's Model Name                             AcQSim
(0010,0000) Patient Group Length                                  60
(0010,0010) Patient's Name
(0010,0020) Patient's ID                                          110-57-66-
(0010,0030) Patient's Birth Date
```

Group: Element:

- Directory contents list: This list displays the contents of the currently selected directory. The user can select a DICOM file from this list. Once a DICOM file has been read, its contents are archived so that subsequent accesses of the file will not require a full re-scan.
- Patient, date, and contour lists: Once a DICOM RT structure set file has been selected in the Directory contents list, the contents of the file are read and displayed in these fields. The uneditable patient and date fields show information about the file, while the contours list shows the individual contours that are present in the file.
- Load button: To load data, select the desired one or more **CONTOURS** from the contours list and click load. Note: selecting files from the directory contents list and clicking load will **NOT** open data.
- Show DCM contents button: To view the DICOM tags contained in a given file, select the file from the Directory contents list and click the Show DCM contents button. The window at bottom will then be displayed, showing a list of the tags present in the DICOM file, sorted by group and element number. The list can be restricted to specific group and/or element numbers by filling in the appropriate fields at the bottom of the window.

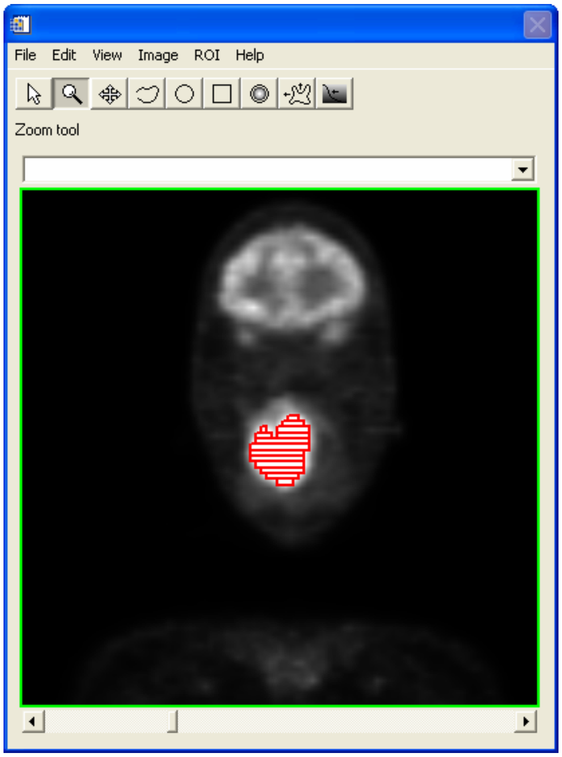
- **ROI representation**



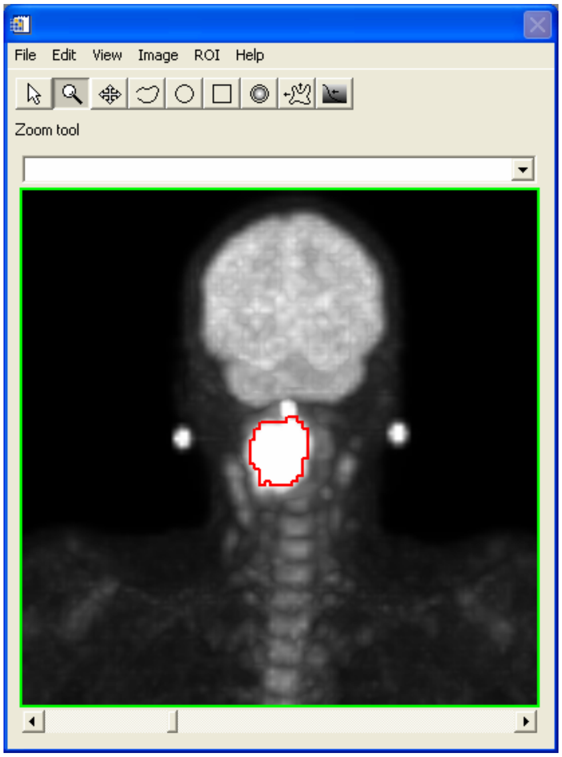
Individual ROIs are represented as a planar, two dimensional closed curve with a fixed thickness. They can therefore be considered slabs. Shown at left is an irregular freehand ROI defined on an axial plane. One can see on the coronal and sagittal views a cross section of this slab ROI by an image plane that is orthogonal to the surface normal of the closed ROI curve.

Image views that are not coplanar with a given ROI will show the corresponding intersection of the ROI with the image plane. When the view type is MIP, surface rendering, or volume rendering, the ROI will be projected onto the image plane rather than sliced. These views are shown below for a composite ROI consisting of slabs defined on adjacent slices.

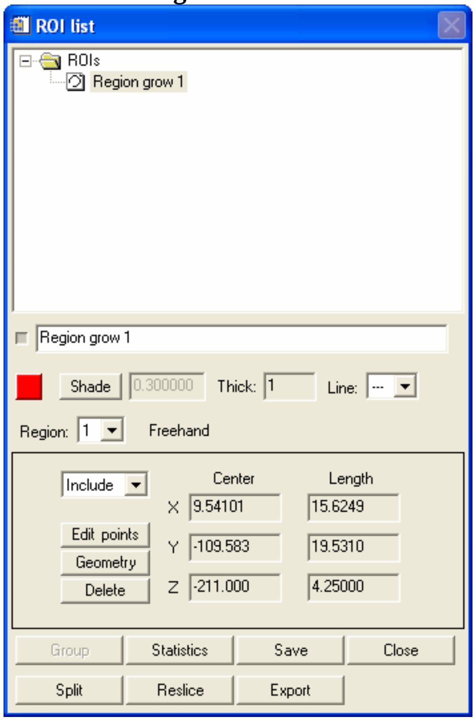
Slice view



MIP view



- **ROI management**



☐ Region grow 1

🟥 Shade 0.300000 Thick: 1 Line: ---

Region: 1 Freehand

Include

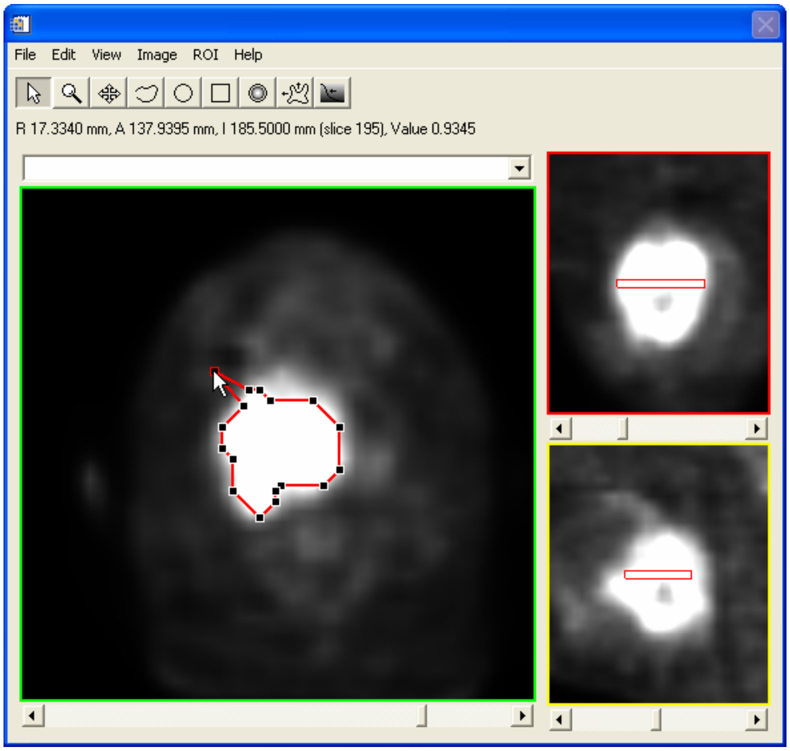
	Center	Length
X	9.54101	15.6249
Y	-109.583	19.5310
Z	-211.000	4.25000

Once an ROI has been opened, imported, or created, and exists within RT_Image, the ROI list becomes visible.

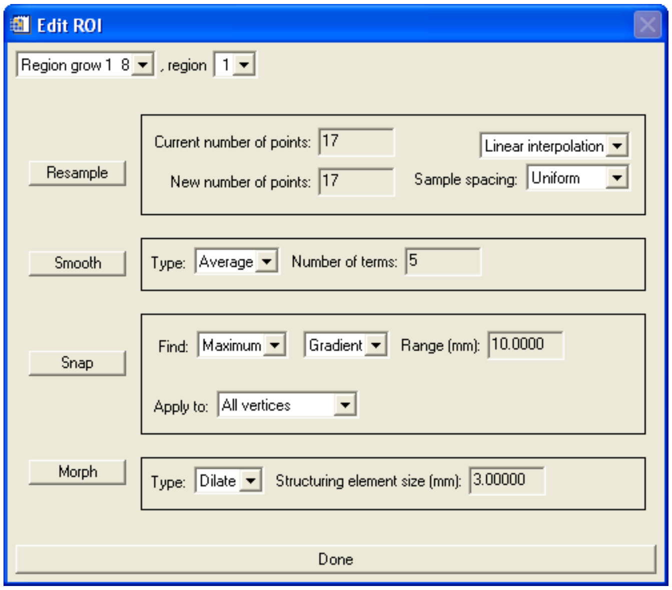
- <u>ROI list</u>: This list shows the currently open ROIs. ROIs can be selected from this list.
- <u>ROI on/off button</u>: The button on the left immediately below the ROI list controls whether the currently selected ROI or ROIs are drawn on the image.
- <u>ROI label field</u>: The field to the right of the ROI on/off button sets the label for the selected ROI.
- <u>ROI display options</u>: The color, thickness, and line style of the currently selected ROI can be manipulated using the controls below the ROI label field. In addition, the user can choose to shade the contents of the currently selected ROI using the Shade button. The transparency of the shading is controlled by the field to the right of the Shade button.

- <u>Region list</u>: The individual regions of a composite ROI can be selected and edited using the droplist below the ROI display options. The type of the currently selected region (freehand, ellipse, or rectangle) is shown in a label to the right of the droplist.
- <u>Region controls</u>
  - <u>Include/Exclude droplist</u>: This option specifies whether the selected region defines image pixels that are or are not contained within the composite ROI. By combining include and exclude regions, one can define donut-shaped composite ROIs.
  - <u>Edit points button</u>: Opens the Edit ROI window, which can be used to manipulate the vertices of the currently selected ROI region.
  - <u>Geometry button</u>: Opens the Geometry window, which can be used to manipulate the orientation of the currently selected ROI region slab.
  - <u>Delete button</u>: Deletes the currently selected ROI region.
  - <u>Center fields</u>: Define the center location of the region. The user can enter values into these fields to translate the region.
  - <u>Length fields</u>: Provide the length in X, Y, and Z of the region. The Z length is defined as the thickness of the region, and can be edited to create larger or smaller slabs. For rectangles and ellipses, the X and Y lengths can also be edited to change the size of the region.
- <u>Group button</u>: Groups the selected ROIs into a single composite ROI.
- <u>Split button</u>: Splits the selected ROI or ROIs into their component individual, single region ROIs.
- <u>Statistics button</u>: Opens the ROI statistics window, allowing analysis of the pixel statistics over the currently selected ROIs.
- <u>Reslice button</u>: Reslices the selected ROI or ROIs according to the current view transformation. For example, if an ROI consisting of a set of axial regions is being viewed coronally, clicking this button will cause the ROI to be reformatted so that it consists of a series of coronal regions.
- <u>Save button</u>: Saves the currently selected ROIs to a ROI file, specific to RT_Image.
- <u>Export button</u>: Saves the currently selectd ROIs into an existing DICOM RT structure set file.
- <u>Close button</u>: Closes the selected ROIs and deletes all data associated with them.

- **Editing ROI vertices**: The vertices of a given ROI region can be manipulated by clicking the Edit points button in the ROI list window.



R 17.3340 mm, A 137.9395 mm, I 185.5000 mm (slice 195), Value 0.9345



Region grow 1 8, region 1

Current number of points: 17

New number of points: 17

Linear interpolation

Sample spacing: Uniform

Type: Average

Number of terms: 5

Find: Maximum

Gradient

Range (mm): 10.0000

Apply to: All vertices

Type: Dilate

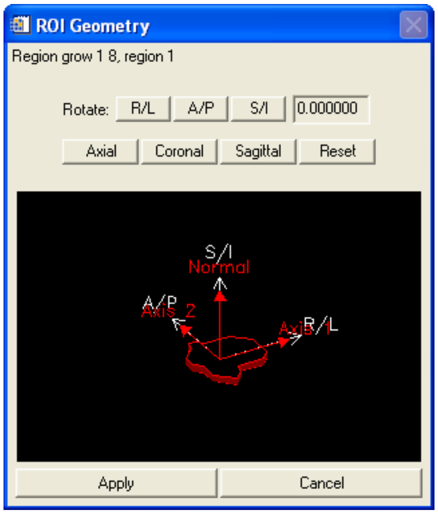
Structuring element size (mm): 3.00000

- Image display window: When in Edit ROI mode, the select tool may be used to left click and drag ROI vertices to new locations. Right clicking on an ROI vertex will delete it from the ROI. The user may alternately right click and drag out a rectangle, which will delete any contained vertices when the right mouse button is released.

Edit ROI window

- ROI, Region droplists: The ROI and region to be edited can be selected using the droplists at the top of the window.
- Resample options: The user may resample the selected ROI region to a new number of vertices using the first set of controls. The user can enter the desired number of new vertices, the type of interpolation to be used, and whether the new samples should be spaced according to their original spacing or uniformly around the ROI curve.
- Smooth options: The user may smooth the vertices of the selected ROI region using an average (boxcar) filter smoothing the specified number of adjacent vertices, or using a Fourier method in which the specified number of low-end frequencies are kept.
- Snap options: Snapping allows the user to adjust the locations of the vertices of an ROI region to specified features of the underlying image. The vertices can be adjusted over the specified range to search for local minima/maxima of the image intensity or gradient. The user can choose to apply this function to all vertices or only to those selected using the left mouse button with the select tool.
- Morph options: The currently selected ROI region can be subjected to morphologic operators including dilation, erosion, opening, and closing, using the specified structuring element size.

- **Editing ROI geometry**: The orientation of the currently selected ROI region can be manipulated by clicking the Geometry button in the ROI list window.



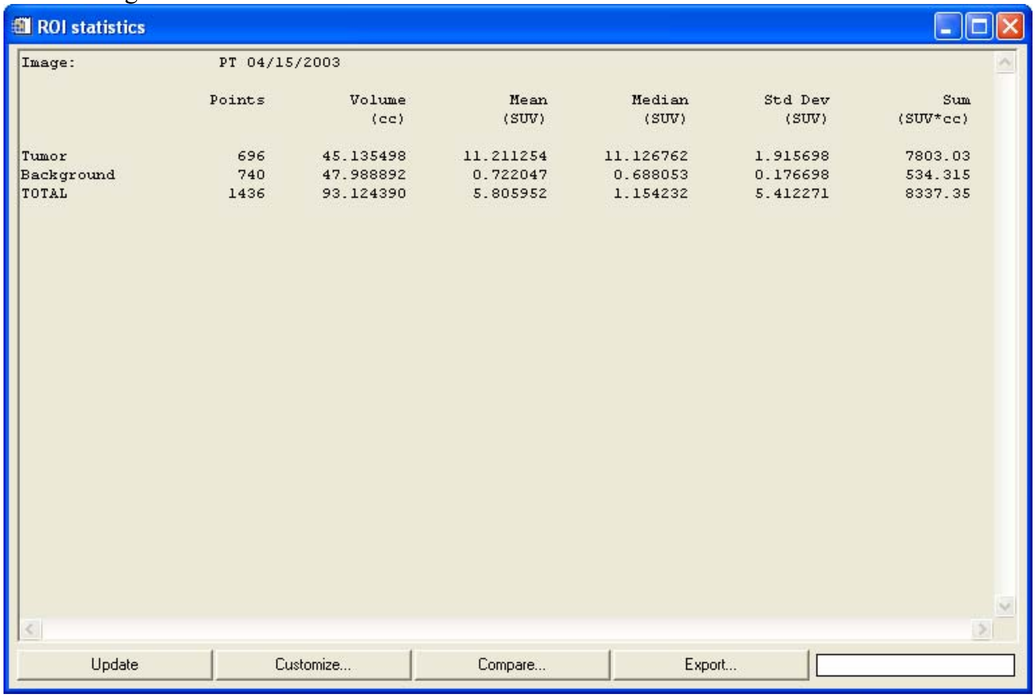
Region grow 1 8, region 1

Rotate: 0.000000

When an ROI is defined, its orientation is by default specified by the view. The normal to the planar ROI curve and its in-plane directional axes is given by the normal and axes of the image view plane. The user can edit this orientation using the Edit ROI geometry window.

- <u>Rotate options</u>: These options allow the user to rotate the ROI region around the specified axis by the specified rotation angle, given in degrees.
- <u>Orientation buttons</u>: The user can shift the ROI region orientation to preset types, including axial, coronal, and sagittal, using the buttons below the rotation options. Alternately, the user can reset the ROI region orientation to its original value by clicking the Reset button.
- <u>ROI geometry window</u>: The user can manually adjust the orientation of the ROI coordinate system by left clicking and rotating the ROI axes within the preview window.

- **Calculating ROI statistics**: Parameters of the image pixel distribution encompassed by one or more ROIs can be calculated by clicking the Statistics button in the ROI list window.



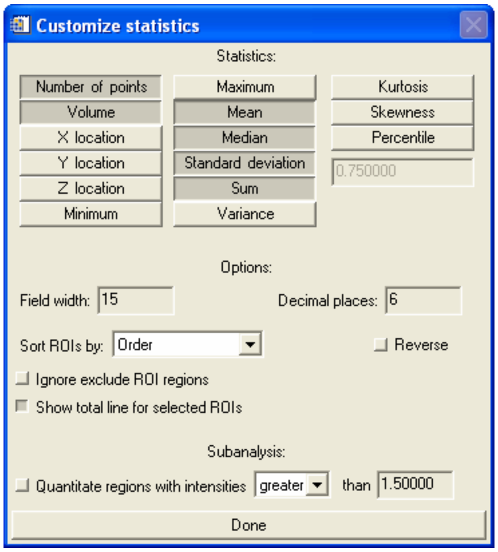
```
Image:              PT 04/15/2003

                    Points       Volume         Mean       Median      Std Dev          Sum
                                   (cc)        (SUV)        (SUV)        (SUV)     (SUV*cc)

Tumor                  696    45.135498    11.211254    11.126762     1.915698      7803.03
Background             740    47.988892     0.722047     0.688053     0.176698      534.315
TOTAL                 1436    93.124390     5.805952     1.154232     5.412271      8337.35
```

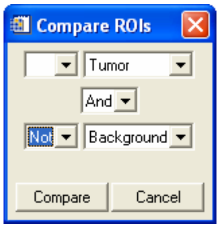
Upon clicking the Statistics button, the values for the currently selected ROI or ROIs are calculated over all open images. They are then displayed in the text field of the ROI statistics window.

- Update button: Recalculates all ROI statistics. Because of the computational burden of performing these calculations, the user must click this button in order to recalculate whenever an ROI is moved or otherwise manipulated.
- Customize… button: Opens the Customize statistics window, allowing specification of the statistics to be displayed and calculation options.
- Compare… button: When statistics for two or more ROIs are displayed, the user may click the Compare button to show the Compare ROIs window, which allows consideration of ROI statistics over unions and intersections of two ROIs.
- Export… button: Allows the user to save either the contents of the ROI statistics text field or the locations and intensities of all image voxels contained within the selected ROIs as a text file. This allows export of the calculations performed within RT_Image to other spreadsheet or analysis software.



Percentile: 0.750000
Field width: 15
Decimal places: 6
Sort ROIs by: Order
☐ Quantitate regions with intensities greater than 1.50000

- Statistics options: Specifies the types of statistics to be displayed for the selected ROIs. When percentile is selected, the percentile to be shown is given in the field beneath the Percentile button.
- Field width field: Specifies the width in characters of each data field for the displayed statistics.
- Decimal places field: Specifies the number of decimal places to be shown when displayed calculated statistics.
- Sort ROIs droplist: Specifies how to order the ROIs when reporting statistics. ROIs can be ordered according to their order in the ROI list, sorted by name, or ordered based on the value of any of the statistics. The selected order can be flipped by checking the Reverse button.
- Ignore exclude ROI regions button: When selected, composite ROIs containing excluded regions will be considered without the exclude regions. That is, statistics for the composite ROI will include any image pixels contained within exclude regions.
- Show total line for selected ROIs button: When selected, an additional line in the ROI statistics display will be shown totalling the values for every ROI over each image.
- Subanalysis options: The user can activate this option to compute statistics for subregions of the currently selected ROIs. These subregions are defined by intensity: the user can choose to examine regions of the selected ROIs with intensities greater or less than a specified value. When activated, the subregion analysis is displayed as an extra line beneath the statistics line for each ROI in the ROI statistics text field.



Tumor
And
Not Background

- Compare ROIs: Using the controls in the Compare ROIs window, the user can construct a logical comparison of two ROIs. This comparison is then used to select a combination of pixels comprising the two ROIs, and statistics for this hybrid pixel distribution is shown as an extra line in the ROI statistics text field.