LIFEx v6.30

MTV protocol

— LIFEx —

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How to use the MTV protocol

LIFEx version 6.30
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LIFEx, MTV protocol
How to extract TLG, MTV, total MTV, and standardised MTV ?

Pre-requisites :

- Create an account on www.lifexsoft.org
- Install the LIFEx software (which includes the MTV calculation protocol)
- Read the tutorial: How to open and view Dicom images *?*
- Read the tutorial: How to draw regions with LIFEx *?*

Loading images

Load PET images first (if needed load CT images second):

- from your local disk
- from a DICOMDIR
- from the network

Or read the tutorial: How to open and view Dicom images *?*

segmentation workflow

3 steps

Step1: Mandatory ROI initialization

- Initialization/creation of ROIs

NB: The resulting volumes can be updated by the user

Step2: Thresholds step

- Semi-automatic segmentation within the initial ROIs with a choice of segmentation methods

NB: The resulting volumes can be updated by the user

Step3: Final step

- Refinement of segmentation results, using pruning, closing, and sorting operations

NB: The refined volumes can still be edited by the user

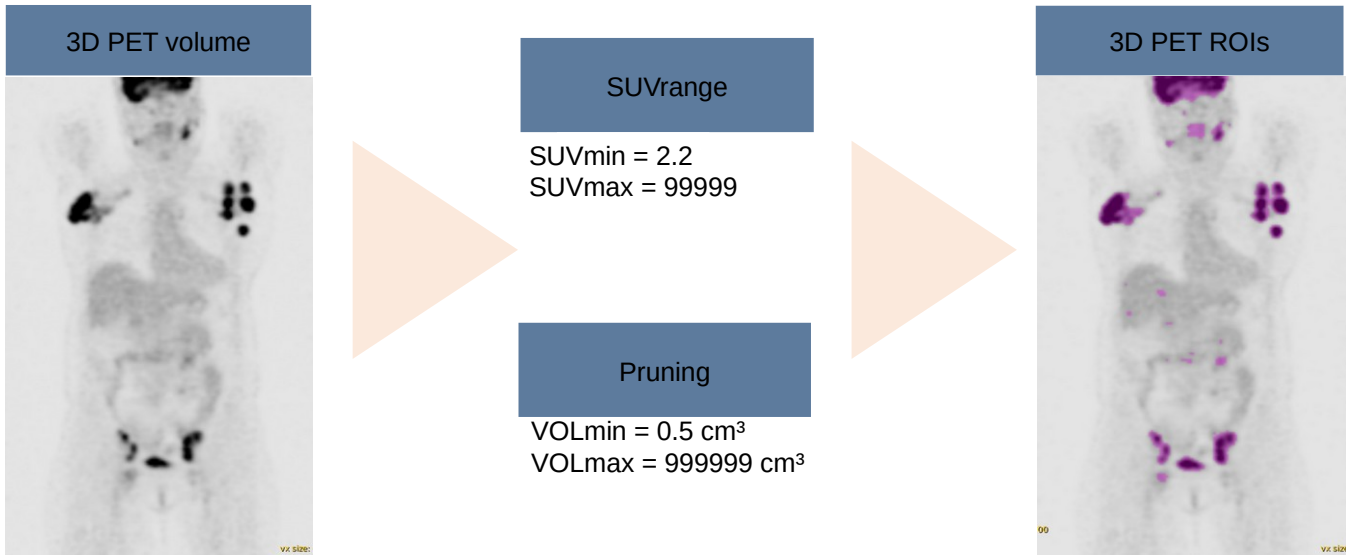
Step 1: ROI initialization

Step 1 is performed each time a total MTV calculation is run.

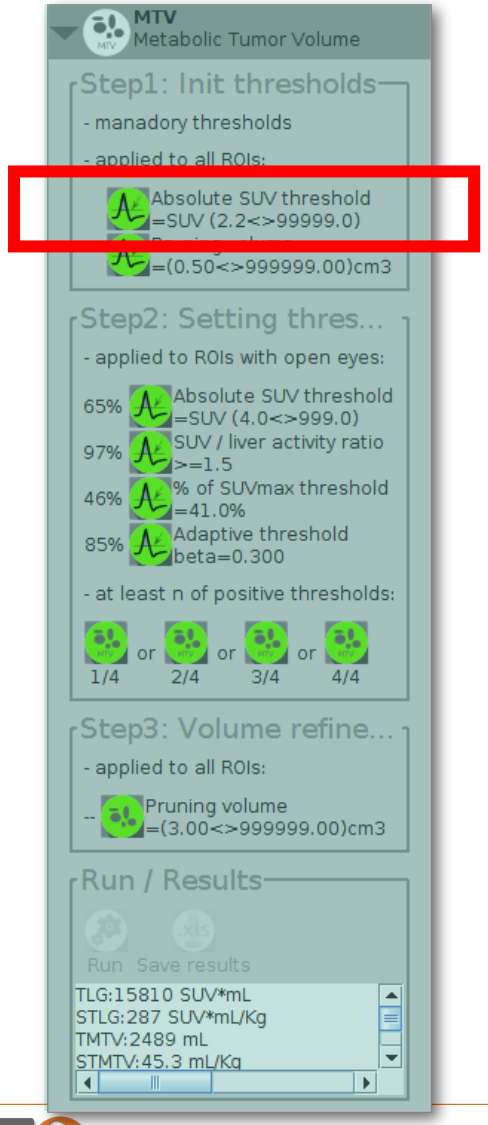
ROI initialization is performed by selecting regions in which SUV varies within a given range, and with a volume belonging to a certain range. These initial ranges are automatically set by the application to 2.2 SUV units and 0.5 mL, with no upper limits.

The resulting volumes can be updated by the user, and can be changed. If ROIs have already been defined in a previous run of the MTV protocol in that session or by loading them from external files, this step can be skipped.

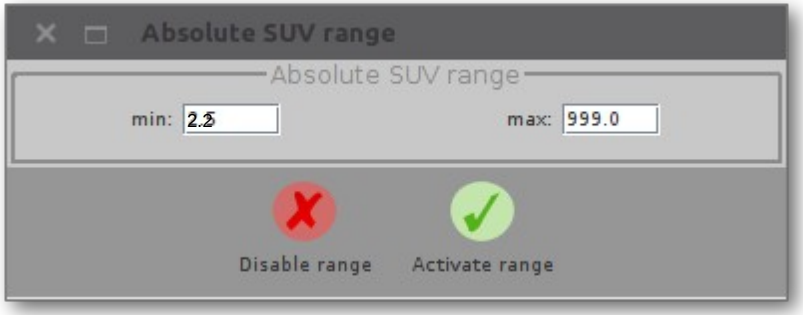
Every time this step is run, you are asked whether you want to remove any existing ROI.



Step 1:
ROI initialization + using the SUV criterion



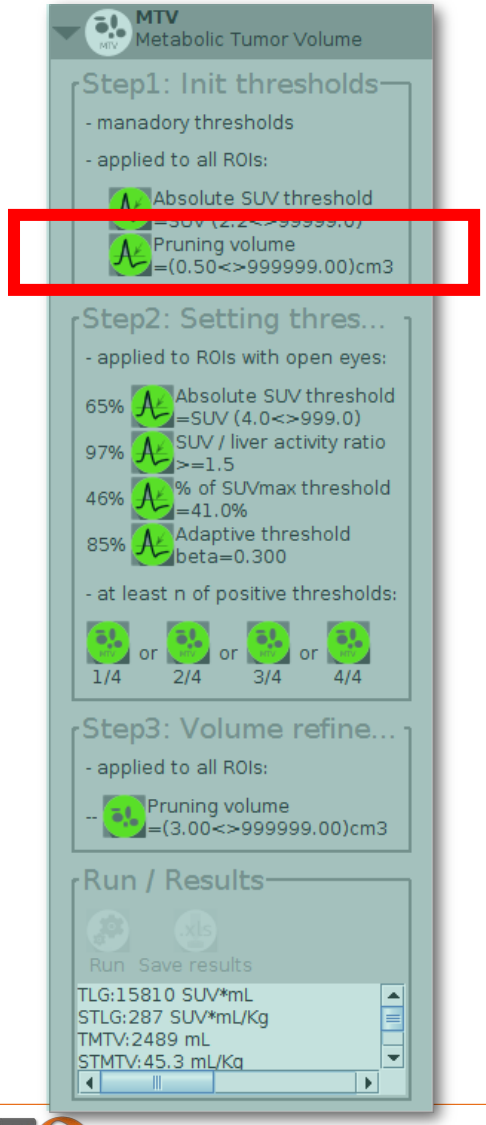
You can change the SUVmin in step 1.
The lowest bound is set to SUV=1.5.



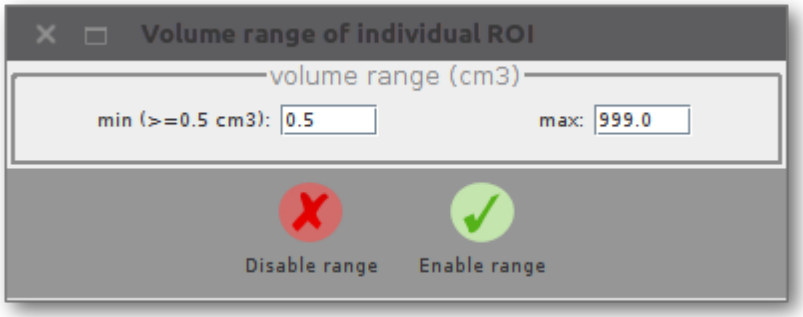
If you do not know the SUVmax threshold value,
keep 999 value in the "max" field.

Here, the MTV volume will be calculated by keeping all connected voxels with an SUV greater than 2.2.

Step 1:
ROI initialization + using the pruning criterion



You can also change the Pruning volume in Step 1.
The lowest bound is set to 0.5 mL.

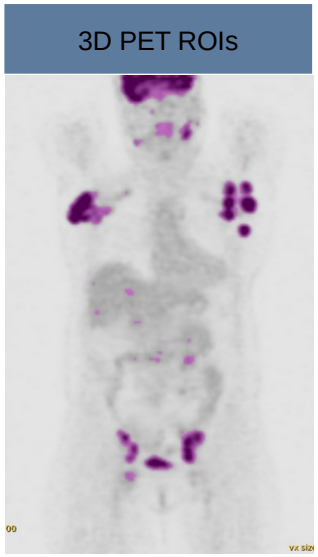


Click on the Disable Range button if you do not want to operate a volume selection at this level.

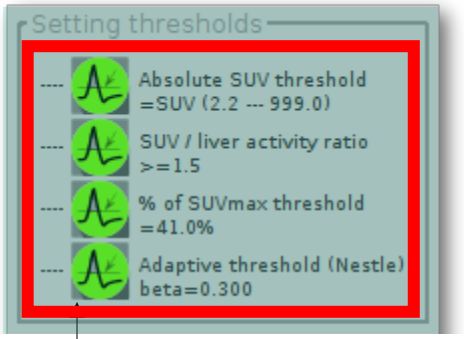
Step 2: Thresholds step

This step is performed each time you rerun the MTV calculation. It allows you to select one or several segmentation methods that will operate within each initial ROI resulting from the previous step.
The cut-off values in minimum SUV (*SUVmin)* and Volume (*Vol)* can be defined by the user. The resulting volumes will be identical to or smaller than those of the initial ROIs.

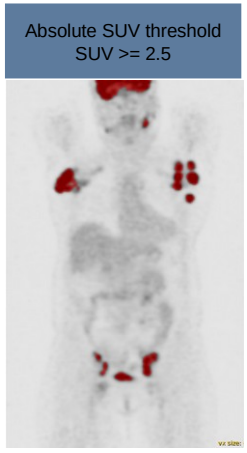
For instance, in the example below, 4 sets of MTV will be generated. In the first set, only voxels with a value greater than 2.5 will be kept. In the second set, only voxels with an SUV greater than 1.5 times the liver activity will be kept. In the third set, only voxels with an SUV greater than 0.7 SUVmax of the region will be kept, while the fourth set of ROIs will be obtained by applying the Nestle method in each initial ROI.

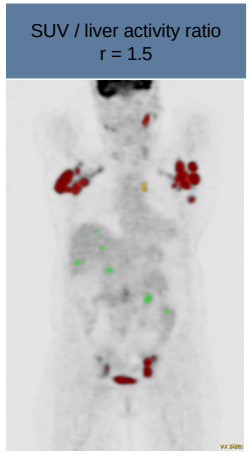


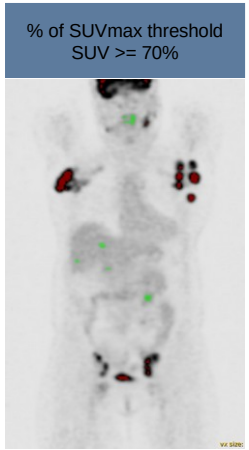
4 thresholds allowing

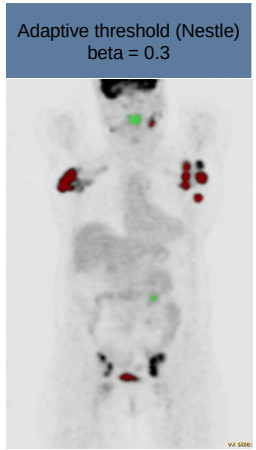


The green circle indicates an activated threshold

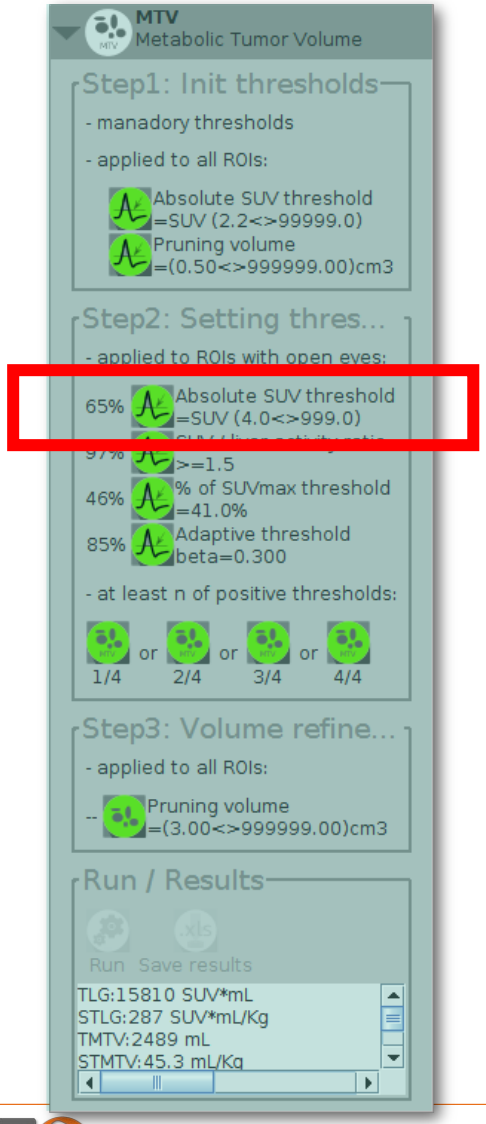


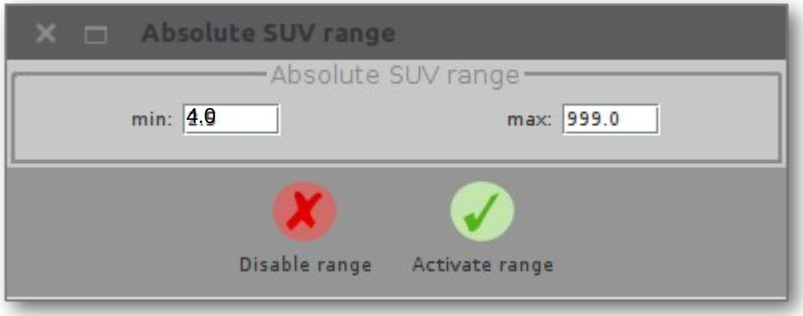






If using the absolute SUV range, set the range values.

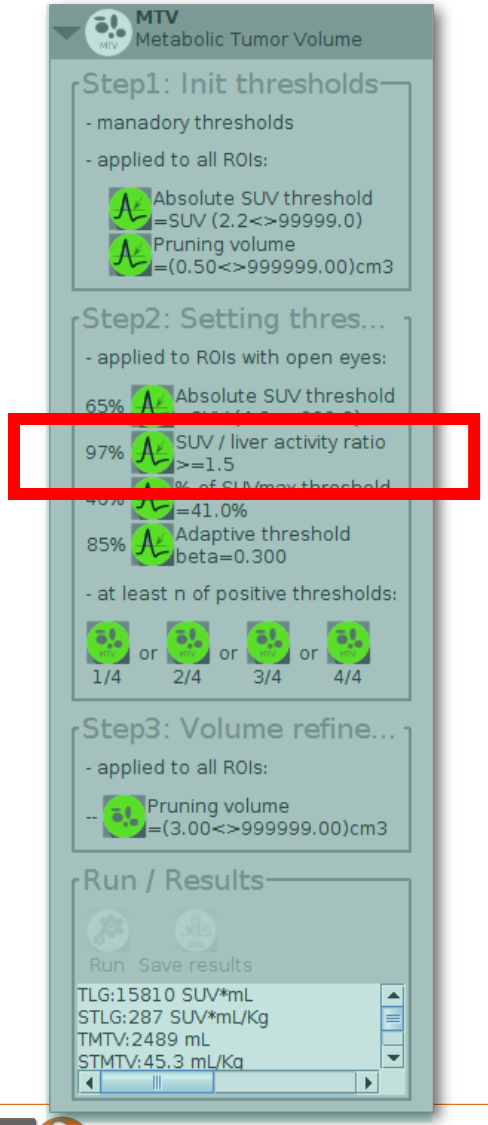


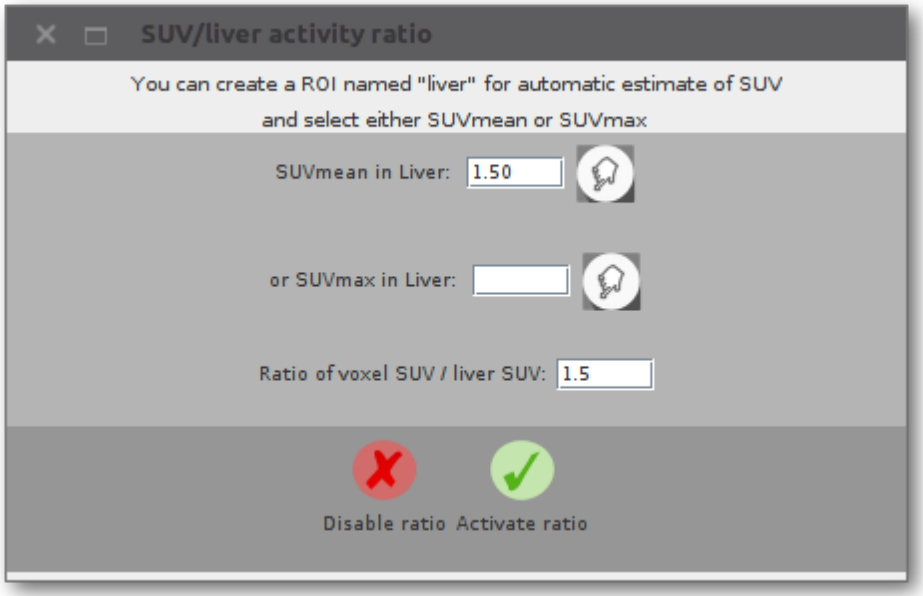


If you do not know the SUVmax threshold value, keep 999 value in the "max" field.

Here, the MTV volume will be calculated by keeping all connected voxels with an SUV greater than 4.

If using the SUV / liver activity ratio method, set the mean or max liver SUV, and the desired ratio.

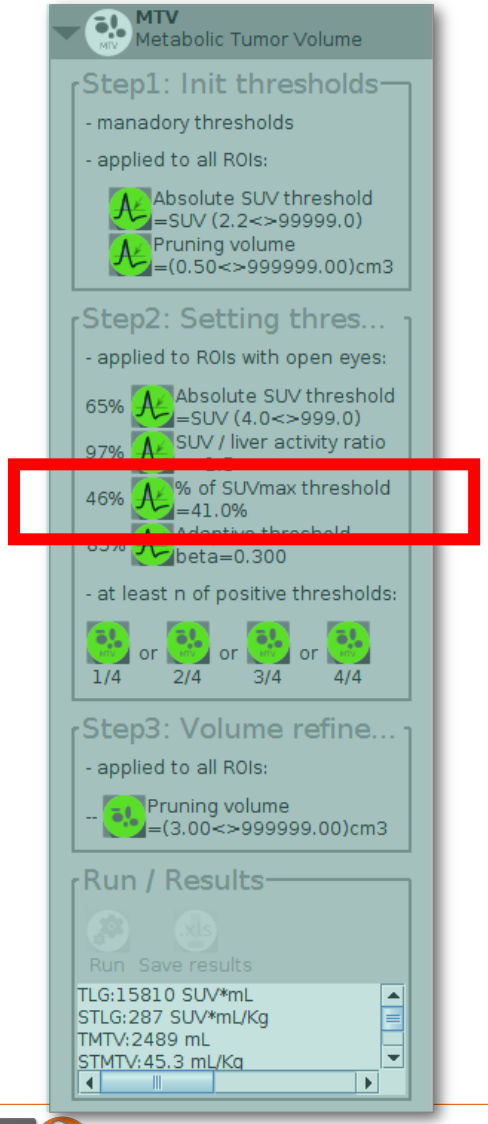


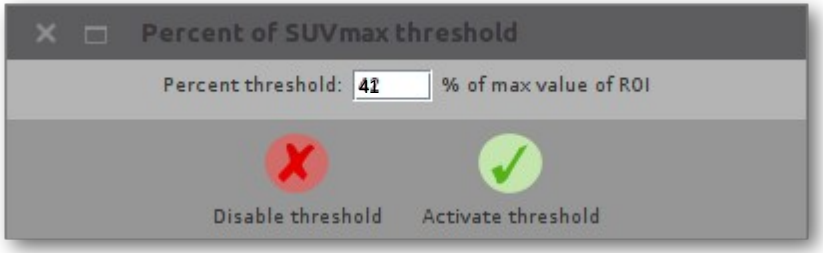


If an ROI named "liver" is found, you can automatically estimate the SUV from that ROI by selecting either SUVmean or SUVmax. When you select the hand icon, you can also manually set the liver mean or max value.

For instance, in the panel above, all voxels with an SUV greater than 1.5 (ratio of voxel SUV / liver SUV) x 1.5 (SUVmean in the liver) will be kept in the ROIs.

If using the percent of SUVmax threshold, set the percent value.





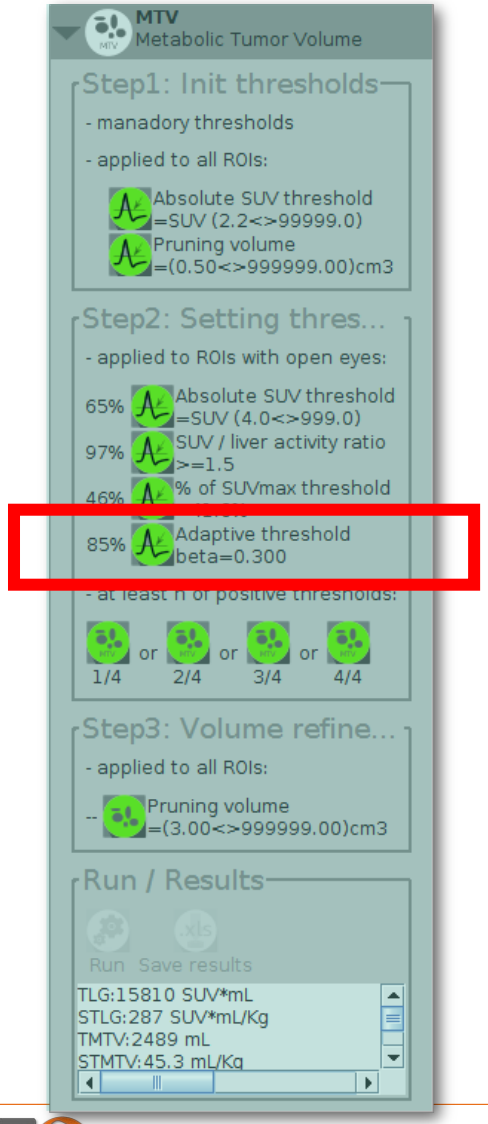
Here, only voxels with an SUV greater than 41% of SUVmax of the initial ROIs will be kept. This applies to each initial ROI independently.

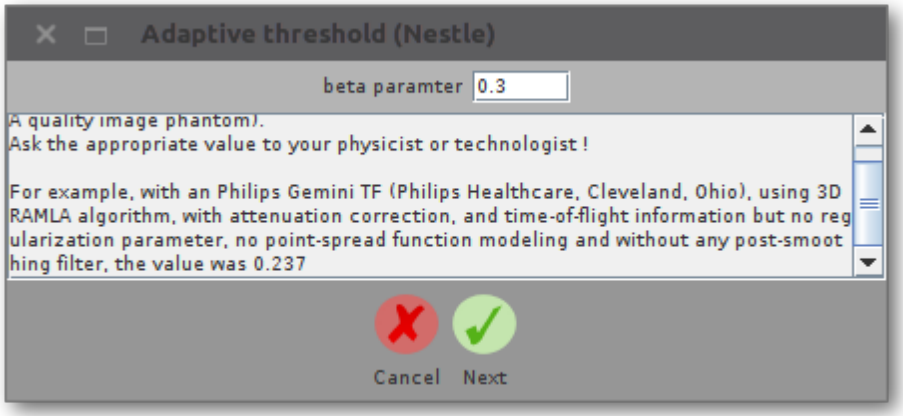
User guide

MTV protocol

— LIFEx —

If using the adaptative threshold (Nestle), set the beta parameter.

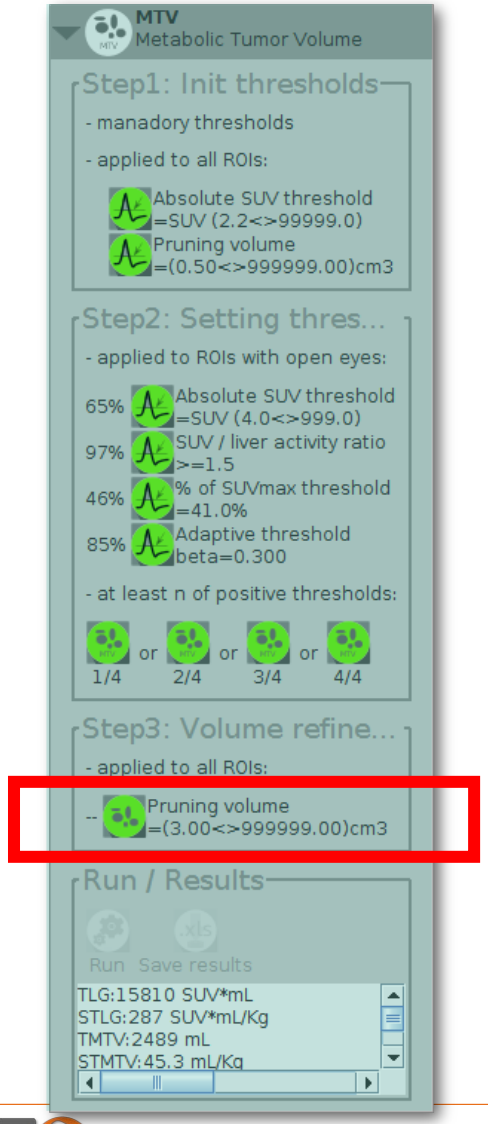


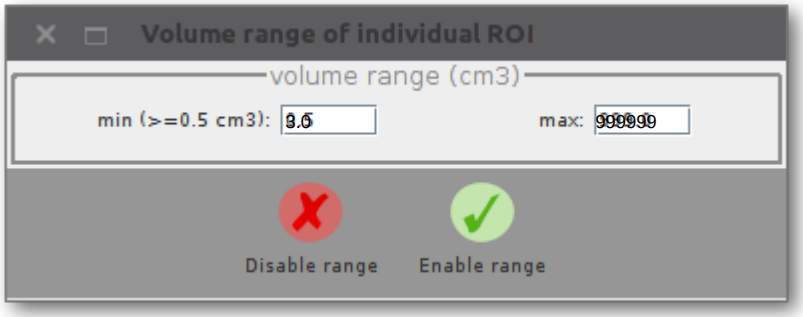


In the Nestle adaptive method (ref of Nestle), you have to set a beta value that has to be calibrated using a phantom experiment or a training dataset.

Then, all voxels included in the Nestle volume (subvolume of the initial ROI) will be kept to obtain the MTV.

If using the pruning criterion, set the acceptable range of volume values.



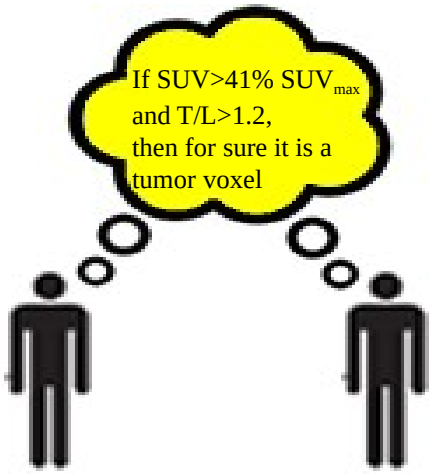


Click on the Disable Range button if you do not want to operate a volume selection at this level.

Towards cooperative approaches

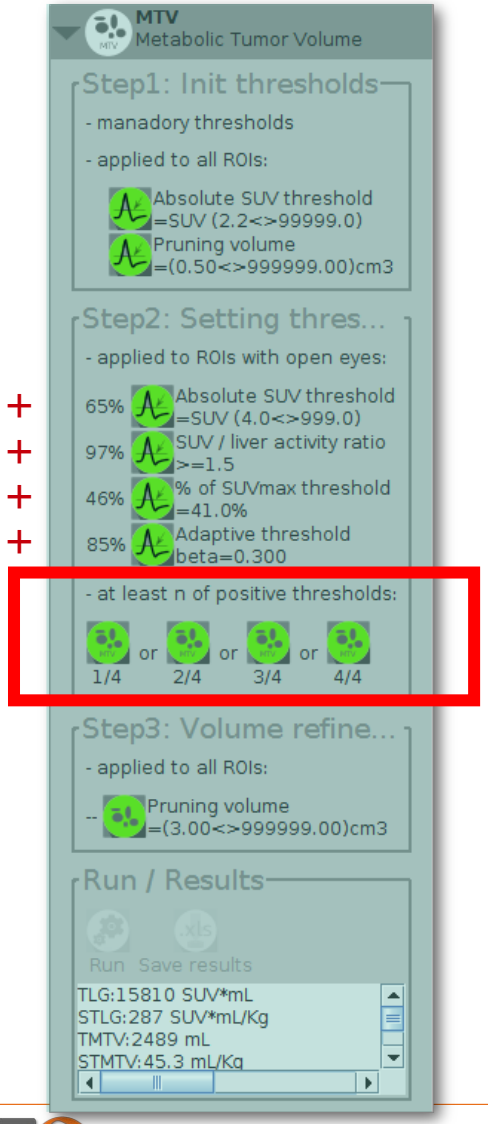
The software includes a cooperative method that takes advantage of the different volume estimates (only if you selected several segmentation methods in the second step) to try identify the best volume estimate.

competition strategy



cooperation strategy

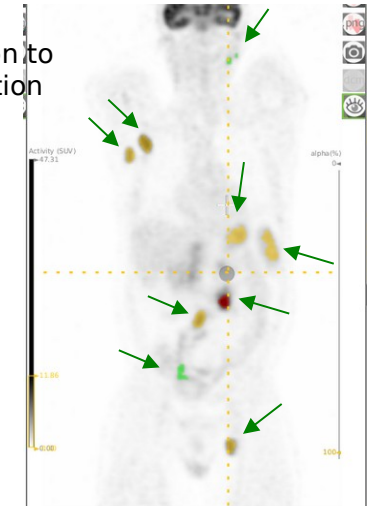
Setting a cooperative approach



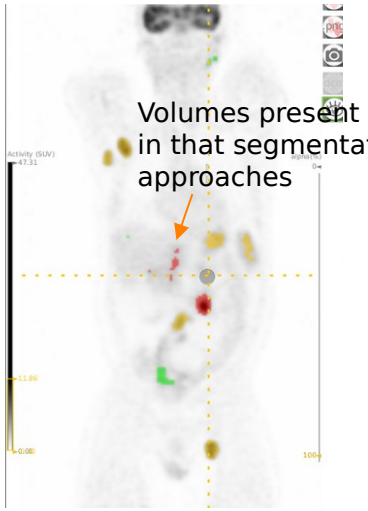
In the Setting thresholds panel, you can set how you want to obtain your final TMTV estimate based on the different segmentation methods you selected:

If you select 4/4, TMTV is defined by all voxels selected as belonging to the MTV by all segmentation methods previously checked.
Similarly, if you select 3/4, TMTV is defined by all voxels selected as belonging to the MTV by at least 3/4 of segmentation methods previously checked (3 out of 4 if you checked all 4 methods).

Volumes common to the 2 segmentation approaches



Volumes present only in that segmentation approaches



41%

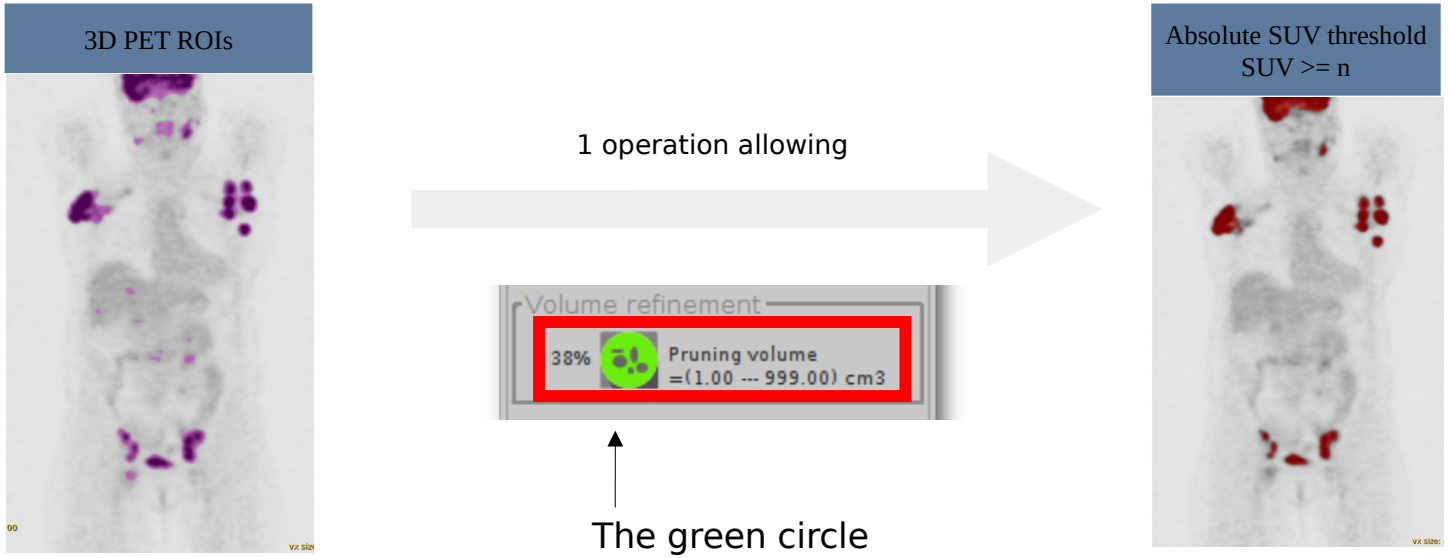
T/L>1.25

Step 3: Third and final step

This step is performed each time a total MTV calculation is run.

The minimum and maximum volume for the final regions entering the TMTV calculation can be set. They have to be equal to or greater than the lower volume bound set in the ROI initialization (step 1) for the minimum volume, and equal to or lower than the upper volume bound set in the ROI initialization.

For instance here, all volumes greater than 1 mL will be kept and used to calculate the total MTV calculation.



Initial ROIs
(cf. B: Secondary workflow)

The green circle indicates an activated operation

Sorting ROI

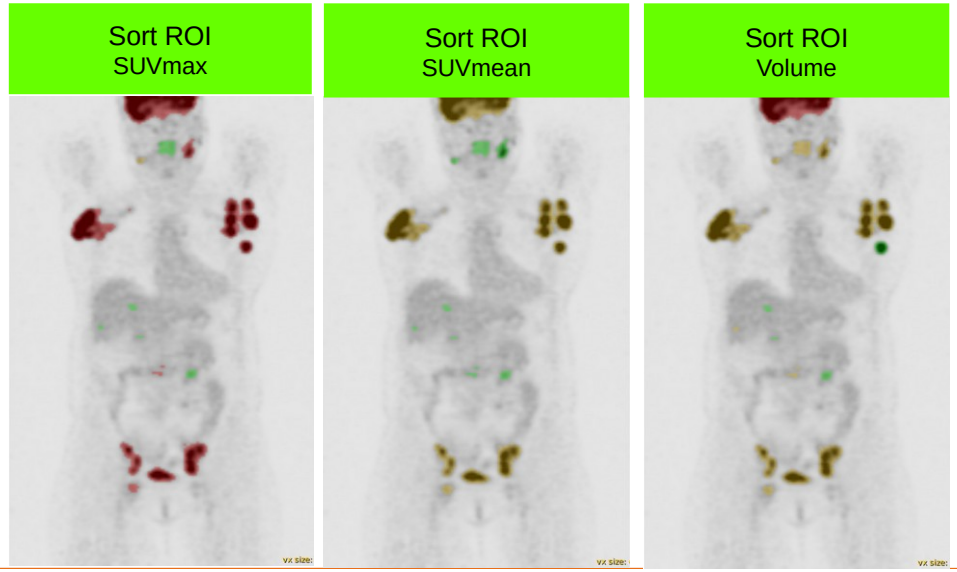
Sometimes, it is useful to look at the list of metabolic volumes by sorting them.

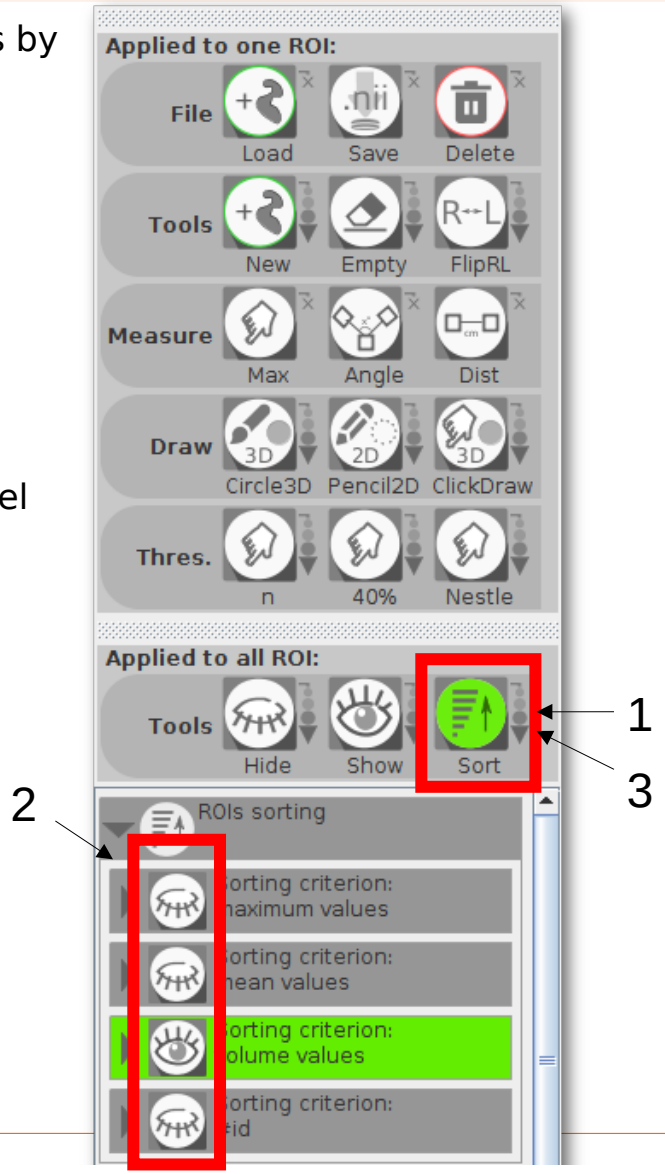
1) This is possible using the Sort button in the ROI panel.

2) Several sorting criteria can be used:
- sorting based on the SUVmax in each volume,
- based on the SUVmean,
- based on the ROI volume
- or based on the #id (single identifier) of the ROI

3) the Sort button can be used for hiding the ROIs sorting panel

Several examples :

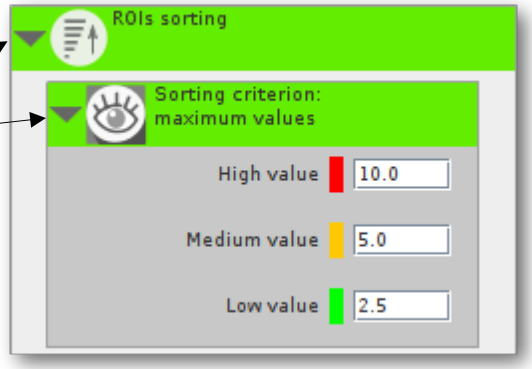


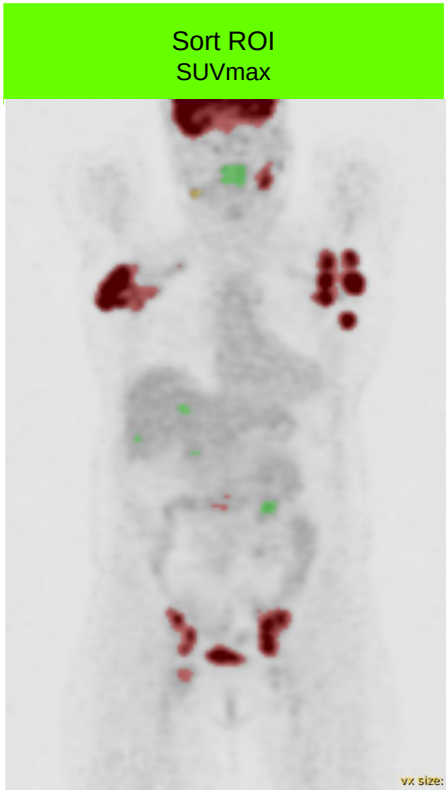


If using the sorting criterion : SUVmax choose the high, medium, low cut-off values that will set the color representation

For instance here,
all regions with an SUVmax greater than 10 will be shown in red,
all those with an SUVmax between 5 and 10 will be shown in orange,
and all with an SUVmax between 2.5 and 5 will be shown in green.

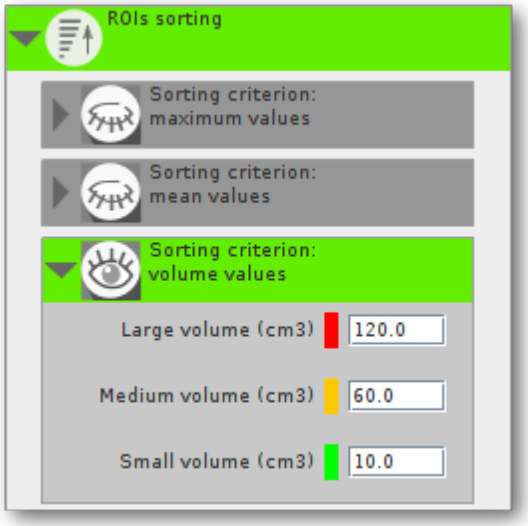
Click on the arrow to set the cut-off values.

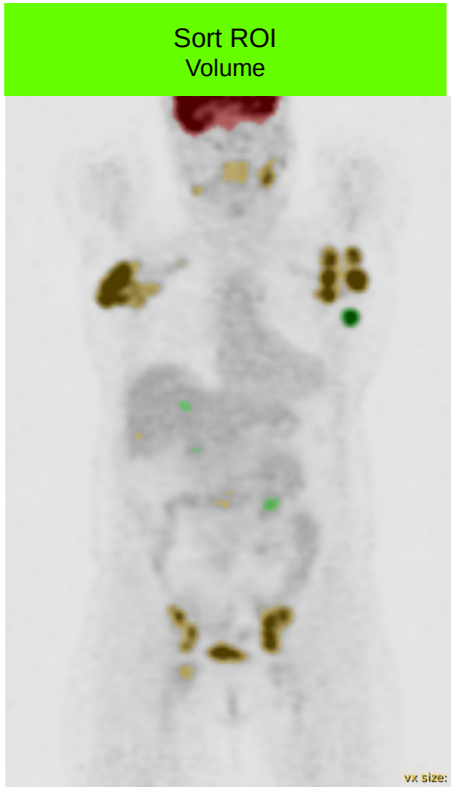




If using the sorting criterion : Volume choose the high, medium, low cut-off values that will set the color representation

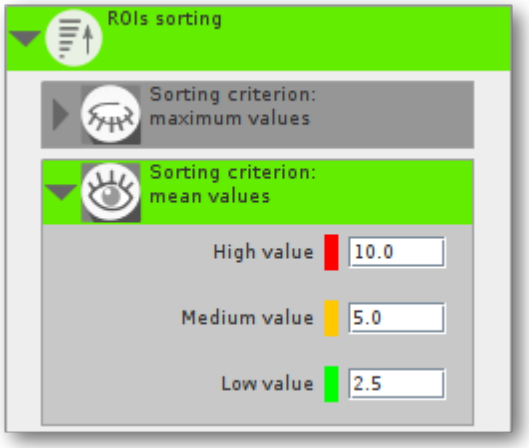
Here,
all regions with a volume greater than 120 mL will be shown in red,
all those with a volume between 60 and 120 mL will be shown in orange,
and all with a volume between 10 mL and 60 mL will be shown in green.

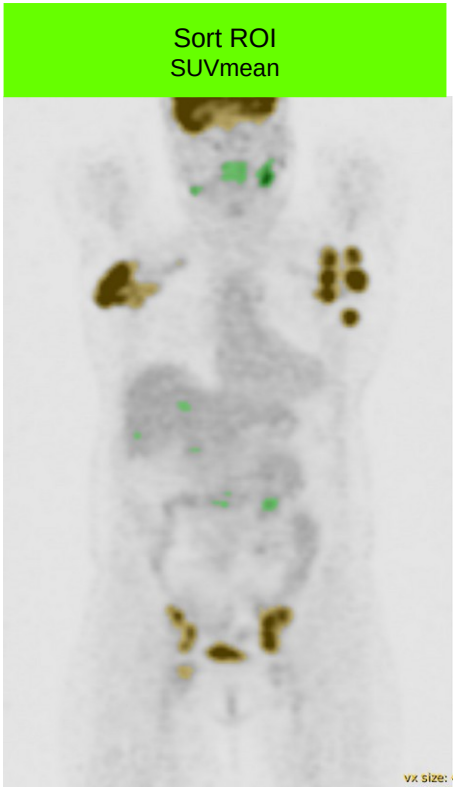




If using the sorting criterion : SUVmean choose the high, medium, low cut-off values that will set the color representation

Here,
all regions with an SUVmean greater than 10 will be shown in red,
all those with an SUVmean between 5 and 10 will be shown in orange,
and all with an SUVmean between 2.5 and 5 will be shown in green.

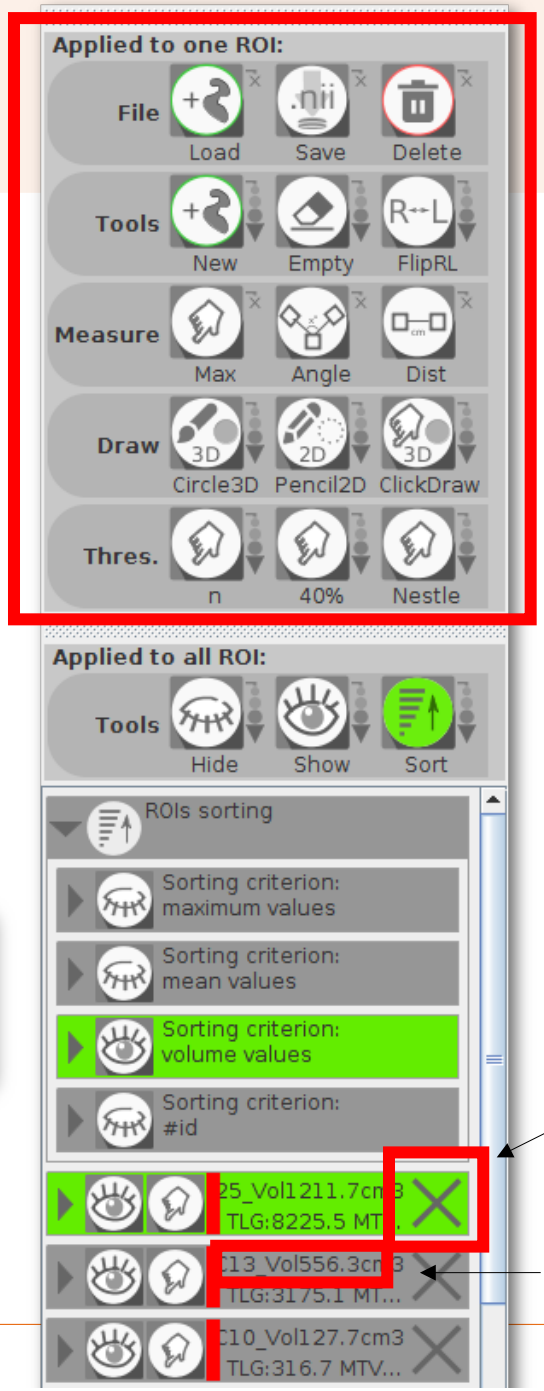


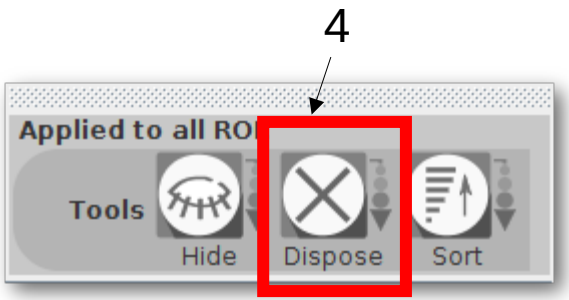


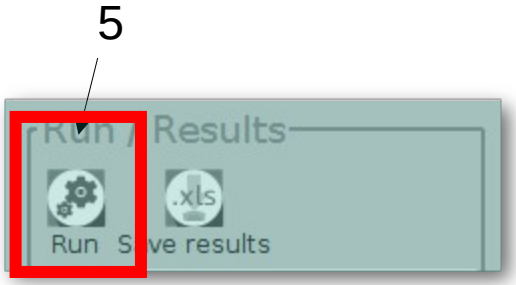
ROI manipulation

You can manipulate the segmentation results (ROIs) to refine your results:

1) Change the ROI bounds using the ROI toolbox
2) Delete the ROI
3) Rename the ROI
   (warning ! ROI sorting renames automatically all ROIs)
4) Erase all the ROIs
5) Repeat the whole TMTV calculation workflow



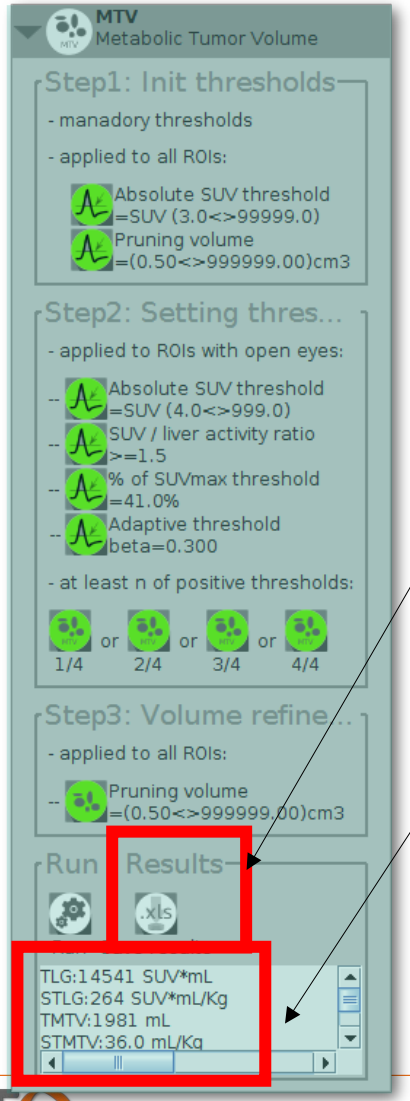




All TLG, TMTV, STMTV are automatically recalculated after ROI are changed

Read the tutorial: How to draw regions with LIFEx ?

Look at the MTV results



Save the results obtained for each ROI in an Excel file

Several results :

MTV: Metabolic Tumor Volume (of each ROI), not shown here
= volume

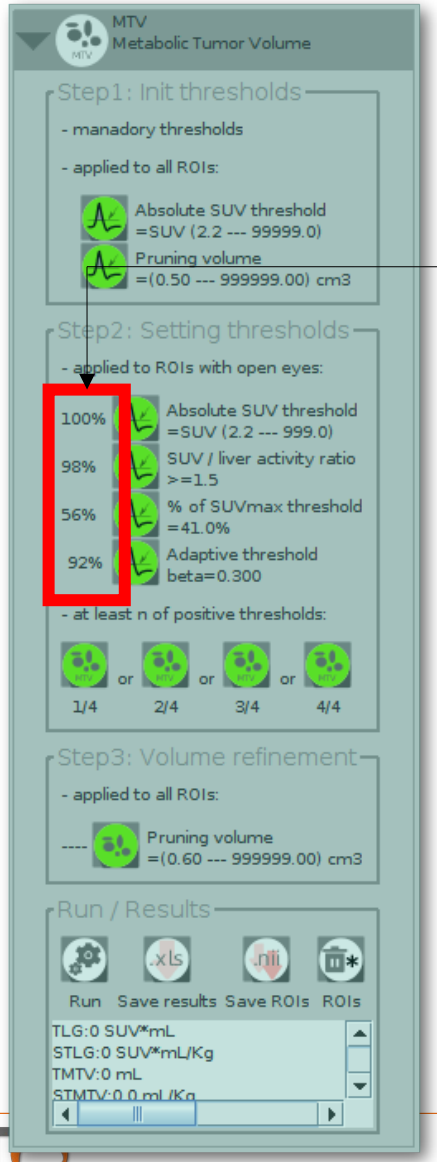
TLG: Total Lesion Glycolysis
= sum of all SUVmean * MTV

TMTV: Total Metabolic Tumor Volume
= sum of all MTV

STMTV: Standardized Total Metabolic Tumor Volume
= TMTV / Patient Weight

STLG (not show): Standardized Total Lesion Glycolysis
= TMTV / Patient Weight

Look at the MTV results



Interpretation of the percentages shown at the left of the theshold icons:

The percentage corresponds to the percent of voxels kept after the step1 operation, with respect to the number of voxels in the step1 ROIs.

Here,

the absolute threshold criterion kept 100% of the step1 voxels.
the SUV/liver activity ratio criterion kept 98% of the step1 voxels.
the %SUVmax threshold criterion kept 100% of the step1 voxels.
the adaptative threshold criterion kept 92 % of the step1 voxels.

After the pruning volume operation, only 38% of the number of voxels in the step1 ROIs were kept.

If you have questions, please read the online documentation:
https://www.lifexsoft.org/index.php/resources/documentation

or contact us: contact@lifexsoft.org