



# LIFEx v6.30

MTV protocol

— LIFEx —

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## How to use the MTV protocol



LIFEx version 6.30

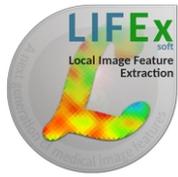
Last update of document: 2020/08/25

LIFEx, MTV protocol

How to extract TLG, MTV, total MTV, and standardised MTV ?

Pre-requisites :

- Create an account on [www.lifexsoft.org](http://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 ?](#)



## User guide

MTV protocol

— 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 ?](#)



# User guide

MTV protocol

— LIFEx —

# segmentation workflow

3 steps

## Step1: Mandatory ROI initialization

- Initialization/creation of ROIs

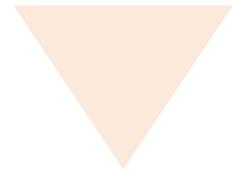
NB: The resulting volumes can be updated by the user



## 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



# User guide

MTV protocol  
— LIFEx —

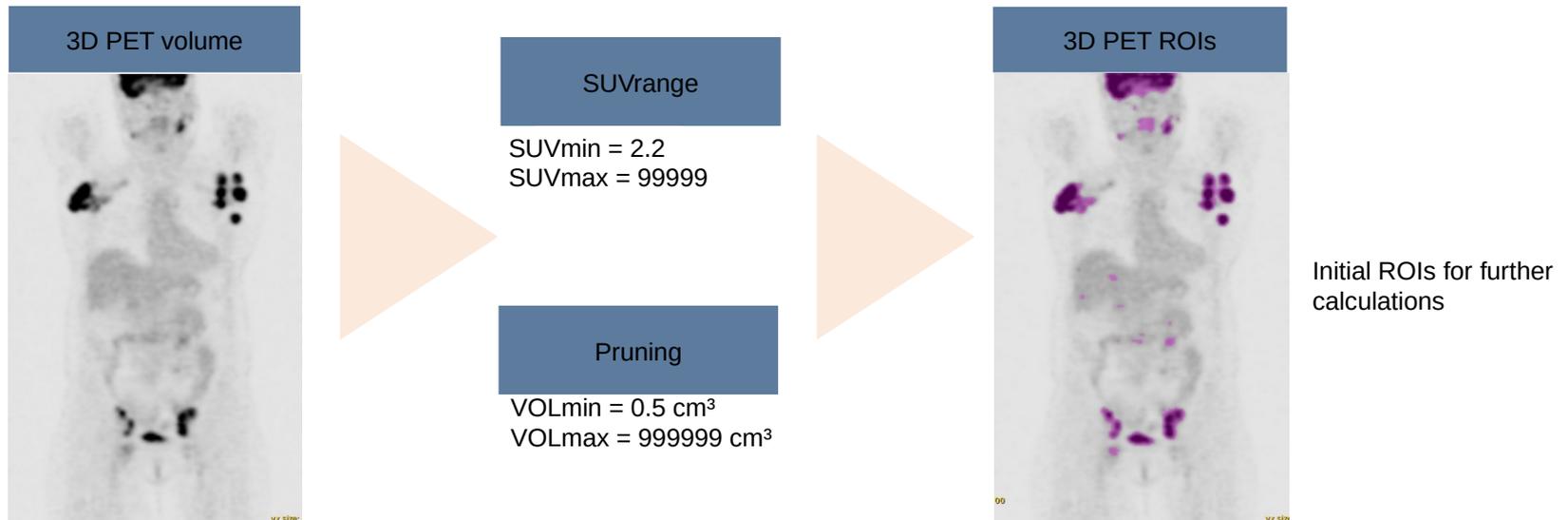
## Step 1: ROI initialization

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.





# User guide

MTV protocol

— LIFEx —

## Step 1: ROI initialization + using the SUV criterion

MTV  
Metabolic Tumor Volume

Step1: Init thresholds

- mandatory thresholds
- applied to all ROIs:
- Absolute SUV threshold = SUV (2.2<->99999.0)**
- Pruning volume = (0.50<->999999.00)cm3

Step2: Setting thres...

- applied to ROIs with open eyes:
- 65% Absolute SUV threshold = SUV (4.0<->999.0)
- 97% SUV / liver activity ratio >=1.5
- 46% % of SUVmax threshold =41.0%
- 85% Adaptive threshold beta=0.300
- at least n of positive thresholds:
- 1/4 or 2/4 or 3/4 or 4/4

Step3: Volume refine...

- applied to all ROIs:
- Pruning volume = (3.00<->999999.00)cm3

Run / Results

Run Save results

TLG:15810 SUV\*mL  
STLG:287 SUV\*mL/Kg  
TMTV:2489 mL  
STMTV:45.3 mL/Kg

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

Absolute SUV range

Absolute SUV range

min: 2.2 max: 999.0

Disable range Activate range

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.



# User guide

MTV protocol

— LIFEx —

## 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.

MTV  
Metabolic Tumor Volume

Step1: Init thresholds

- mandatory thresholds
- applied to all ROIs:
- Absolute SUV threshold  
=SUV (2.2<->99999.0)
- Pruning volume  
=(0.50<->999999.00)cm3

Step2: Setting thres...

- applied to ROIs with open eyes:
- 65% Absolute SUV threshold  
=SUV (4.0<->999.0)
- 97% SUV / liver activity ratio  
>=1.5
- 46% % of SUVmax threshold  
=41.0%
- 85% Adaptive threshold  
beta=0.300
- at least n of positive thresholds:  
1/4 or 2/4 or 3/4 or 4/4

Step3: Volume refine...

- applied to all ROIs:
- Pruning volume  
=(3.00<->999999.00)cm3

Run / Results

Run Save results

TLG:15810 SUV\*mL  
STLG:287 SUV\*mL/Kg  
TMTV:2489 mL  
STMTV:45.3 mL/Kg

Volume range of individual ROI

volume range (cm3)

min (>=0.5 cm3): 0.5 max: 999.0

Disable range Enable range

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



# User guide

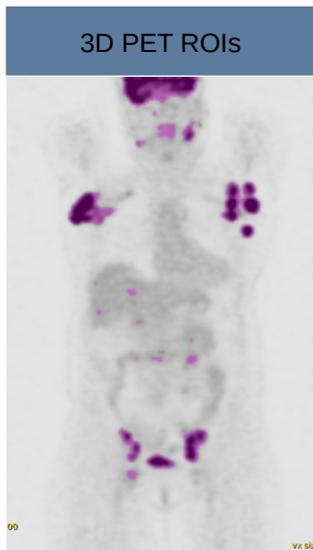
MTV protocol

— LIFEx —

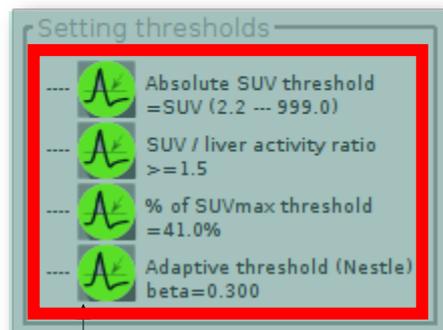
## Step 2: Thresholds step

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 ( $SUV_{min}$ ) 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.

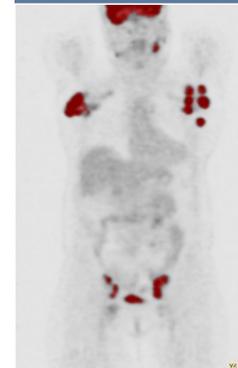


4 thresholds allowing

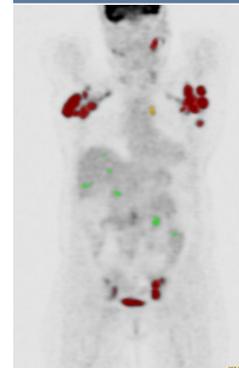


The green circle indicates an activated threshold

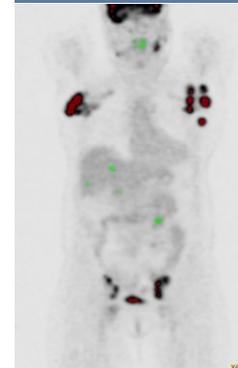
Absolute SUV threshold  
SUV >= 2.5



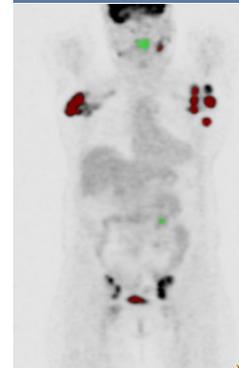
SUV / liver activity ratio  
r = 1.5



% of SUVmax threshold  
SUV >= 70%



Adaptive threshold (Nestle)  
beta = 0.3





# User guide

MTV protocol

— LIFEx —

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

MTV  
Metabolic Tumor Volume

Step1: Init thresholds

- mandatory thresholds
- applied to all ROIs:
- Absolute SUV threshold =SUV (2.2<->99999.0)
- Pruning volume =(0.50<->999999.00)cm3

Step2: Setting thres...

- applied to ROIs with open eyes:
- 65% Absolute SUV threshold =SUV (4.0<->999.0)
- 97% >=1.5
- 46% % of SUVmax threshold =41.0%
- 85% Adaptive threshold beta=0.300
- at least n of positive thresholds:
- 1/4 or 2/4 or 3/4 or 4/4

Step3: Volume refine...

- applied to all ROIs:
- Pruning volume =(3.00<->999999.00)cm3

Run / Results

Run Save results

TLG:15810 SUV\*mL  
STLG:287 SUV\*mL/Kg  
TMTV:2489 mL  
STMTV:45.3 mL/Kg

Absolute SUV range

min: 4.0 max: 999.0

Disable range Activate range

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.



# User guide

MTV protocol

— LIFEx —

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

MTV  
Metabolic Tumor Volume

Step1: Init thresholds

- mandatory thresholds
- applied to all ROIs:
- Absolute SUV threshold =SUV (2.2<->99999.0)
- Pruning volume =(0.50<->999999.00)cm3

Step2: Setting thres...

- applied to ROIs with open eyes:
- 65% Absolute SUV threshold
- 97% SUV / liver activity ratio >=1.5**
- 40% % of SUVmax threshold =41.0%
- 85% Adaptive threshold beta=0.300
- at least n of positive thresholds:
- or or or

Step3: Volume refine...

- applied to all ROIs:
- Pruning volume =(3.00<->999999.00)cm3

Run / Results

Run Save results

TLG:15810 SUV\*mL  
STLG:287 SUV\*mL/Kg  
TMTV:2489 mL  
STMTV:45.3 mL/Kg

SUV/liver activity ratio

You can create a ROI named "liver" for automatic estimate of SUV and select either SUVmean or SUVmax

SUVmean in Liver:

or SUVmax in Liver:

Ratio of voxel SUV / liver SUV:

Disable ratio Activate 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.



# User guide

MTV protocol

— LIFEx —

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

**MTV**  
Metabolic Tumor Volume

**Step1: Init thresholds**

- mandatory thresholds
- applied to all ROIs:
  - Absolute SUV threshold = SUV (2.2<->99999.0)
  - Pruning volume = (0.50<->999999.00)cm<sup>3</sup>

**Step2: Setting thres...**

- applied to ROIs with open eyes:
  - 65% Absolute SUV threshold = SUV (4.0<->999.0)
  - 97% SUV / liver activity ratio
  - 46% % of SUVmax threshold = 41.0%**
  - 65% Adaptive threshold beta=0.300
- at least n of positive thresholds:
  - 1/4 or 2/4 or 3/4 or 4/4

**Step3: Volume refine...**

- applied to all ROIs:
  - Pruning volume = (3.00<->999999.00)cm<sup>3</sup>

**Run / Results**

Run Save results

TLG:15810 SUV\*mL  
STLG:287 SUV\*mL/Kg  
TMTV:2489 mL  
STMTV:45.3 mL/Kg

**Percent of SUVmax threshold**

Percent threshold:  % of max value of ROI

Disable threshold  Activate threshold

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.

MTV  
Metabolic Tumor Volume

Step1: Init thresholds

- mandatory thresholds
- applied to all ROIs:
- Absolute SUV threshold =SUV (2.2<->99999.0)
- Pruning volume =(0.50<->999999.00)cm3

Step2: Setting thres...

- applied to ROIs with open eyes:
- 65% Absolute SUV threshold =SUV (4.0<->999.0)
- 97% SUV / liver activity ratio >=1.5
- 46% % of SUVmax threshold
- 85% Adaptive threshold beta=0.300
- at least n of positive thresholds:
- 1/4 or 2/4 or 3/4 or 4/4

Step3: Volume refine...

- applied to all ROIs:
- Pruning volume =(3.00<->999999.00)cm3

Run / Results

Run Save results

TLG:15810 SUV\*mL  
STLG:287 SUV\*mL/Kg  
TMTV:2489 mL  
STMTV:45.3 mL/Kg

Adaptive threshold (Nestle)

beta paramter 0.3

A quality image phantom).  
Ask the appropriate value to your physicist or technologist !

For example, with an Philips Gemini TF (Philips Healthcare, Cleveland, Ohio), using 3D RAMLA algorithm, with attenuation correction, and time-of-flight information but no regularization parameter, no point-spread function modeling and without any post-smoothing filter, the value was 0.237

Cancel Next

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.



# User guide

MTV protocol

— LIFEx —

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

**MTV**  
Metabolic Tumor Volume

**Step1: Init thresholds**

- mandatory thresholds
- applied to all ROIs:
- Absolute SUV threshold =SUV (2.2<=>99999.0)
- Pruning volume =(0.50<=>999999.00)cm3

**Step2: Setting thres...**

- applied to ROIs with open eyes:
- 65% Absolute SUV threshold =SUV (4.0<=>999.0)
- 97% SUV / liver activity ratio >=1.5
- 46% % of SUVmax threshold =41.0%
- 85% Adaptive threshold beta=0.300
- at least n of positive thresholds:
- or or or   
1/4 or 2/4 or 3/4 or 4/4

**Step3: Volume refine...**

- applied to all ROIs:
- Pruning volume =(3.00<=>999999.00)cm3

**Run / Results**

Run Save results

TLG:15810 SUV\*mL  
STLG:287 SUV\*mL/Kg  
TMTV:2489 mL  
STMTV:45.3 mL/Kg

**Volume range of individual ROI**

volume range (cm3)

min (>=0.5 cm3):  max:

Disable range Enable range

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



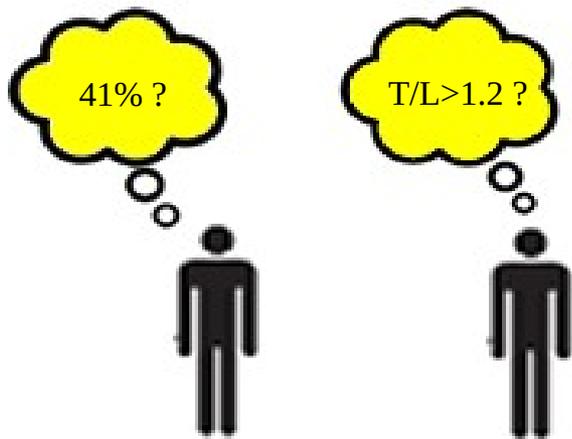
# User guide

MTV protocol

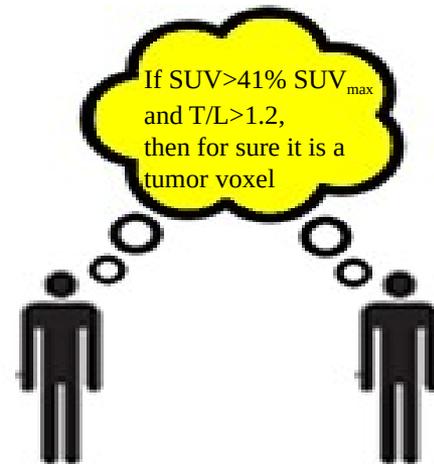
— LIFEx —

## 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



# User guide

MTV protocol

— LIFEx —

## 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).

**MTV**  
Metabolic Tumor Volume

**Step1: Init thresholds**

- mandatory thresholds
- applied to all ROIs:
- Absolute SUV threshold =SUV (2.2<->99999.0)
- Pruning volume =(0.50<->999999.00)cm3

**Step2: Setting thres...**

- applied to ROIs with open eyes:
- 65% Absolute SUV threshold =SUV (4.0<->999.0)
- 97% SUV / liver activity ratio >=1.5
- 46% % of SUVmax threshold =41.0%
- 85% Adaptive threshold beta=0.300
- at least n of positive thresholds:
- 1/4 or 2/4 or 3/4 or 4/4

**Step3: Volume refine...**

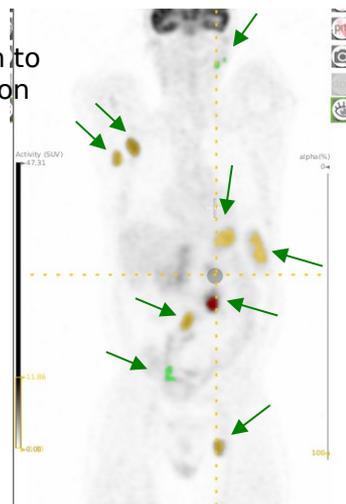
- applied to all ROIs:
- Pruning volume =(3.00<->999999.00)cm3

**Run / Results**

Run Save results

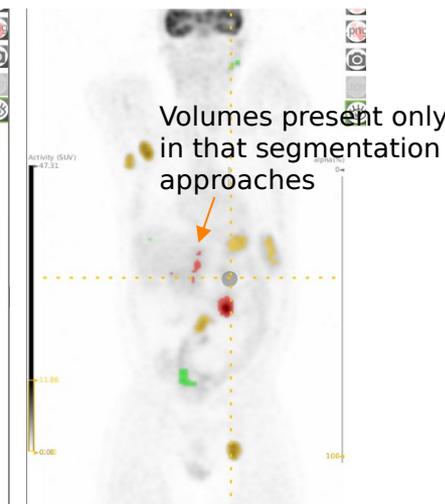
TLG:15810 SUV\*mL  
STLG:287 SUV\*mL/Kg  
TMTV:2489 mL  
STMTV:45.3 mL/Kg

Volumes common to the 2 segmentation approaches



41%

Volumes present only in that segmentation approaches



T/L>1.25



# User guide

MTV protocol

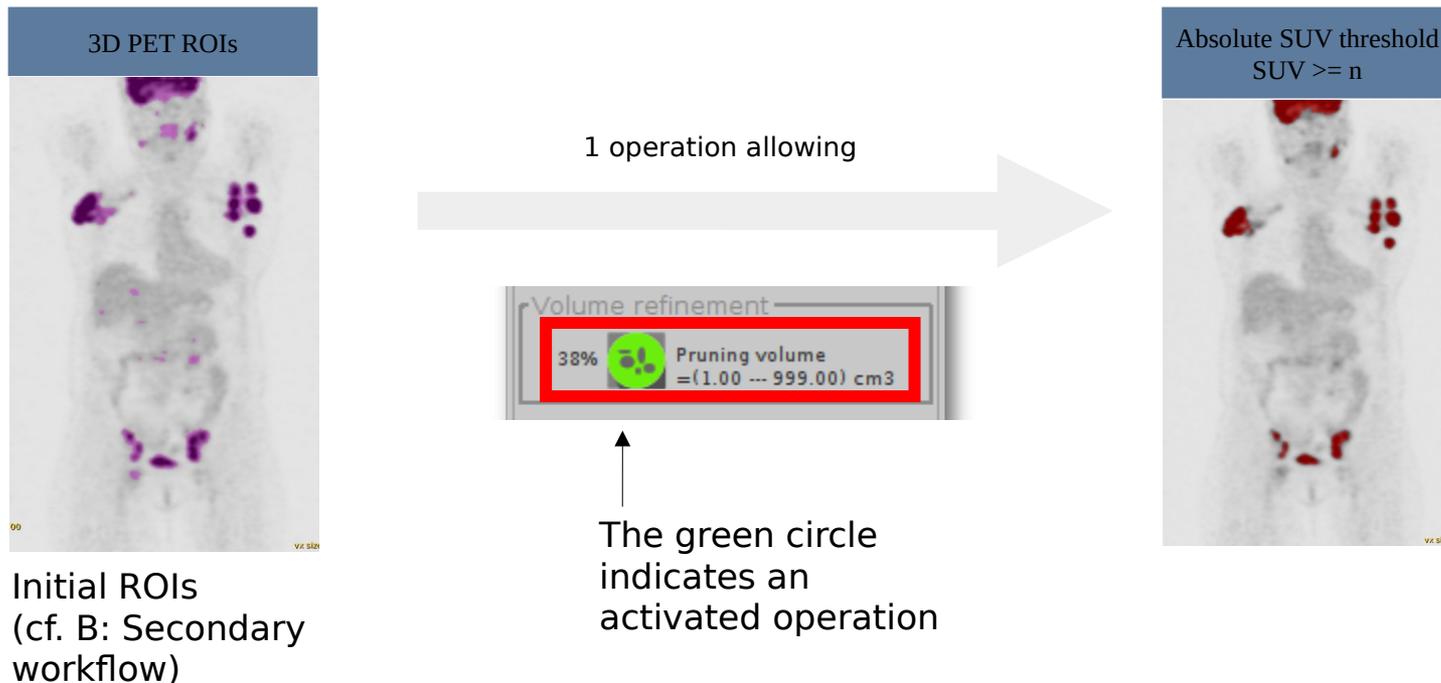
— LIFEx —

## 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



# User guide

MTV protocol

— LIFEx —

## Sorting ROI

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

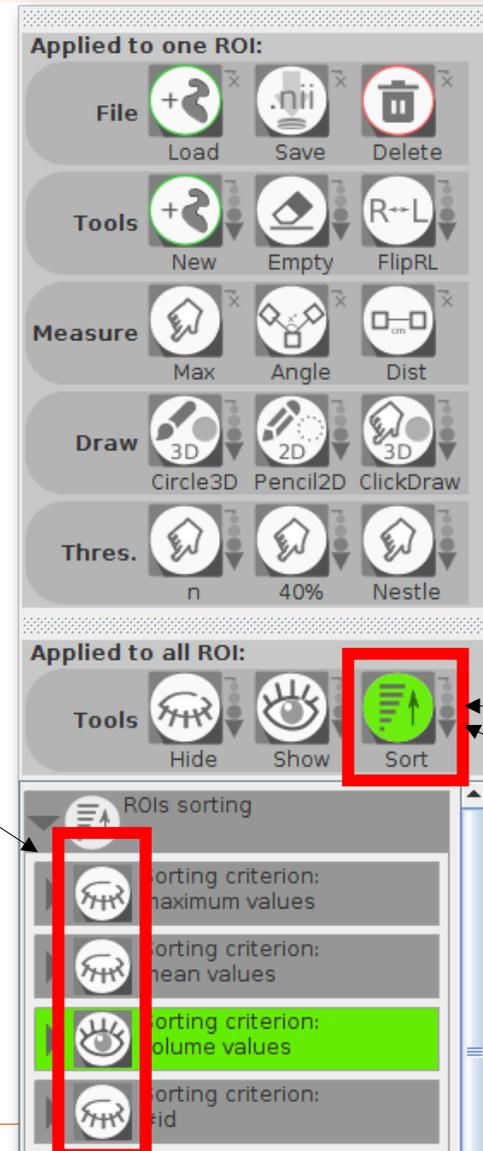
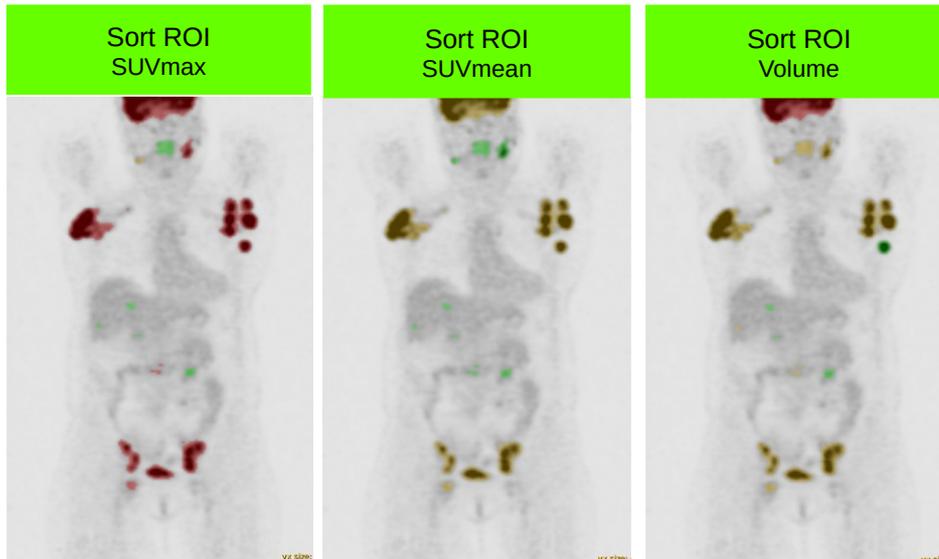
1) This is possible using the Sort button in the ROI panel.

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 :





# User guide

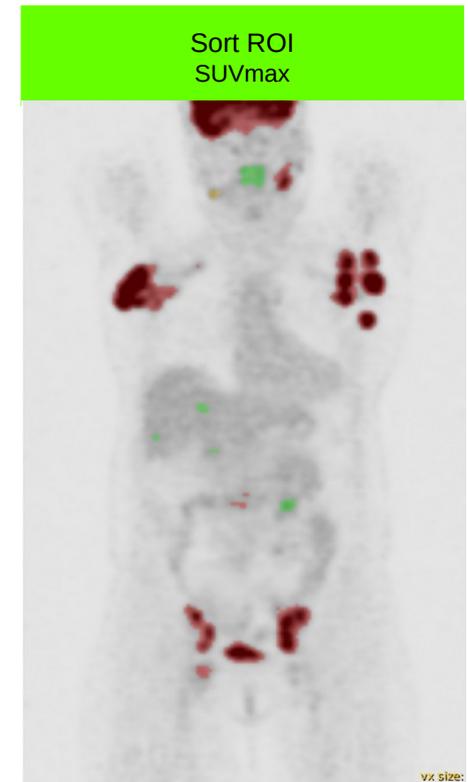
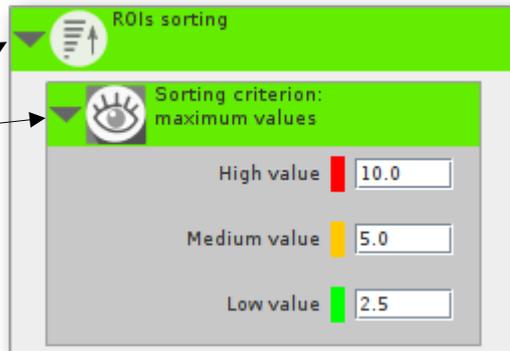
MTV protocol

— LIFEx —

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.





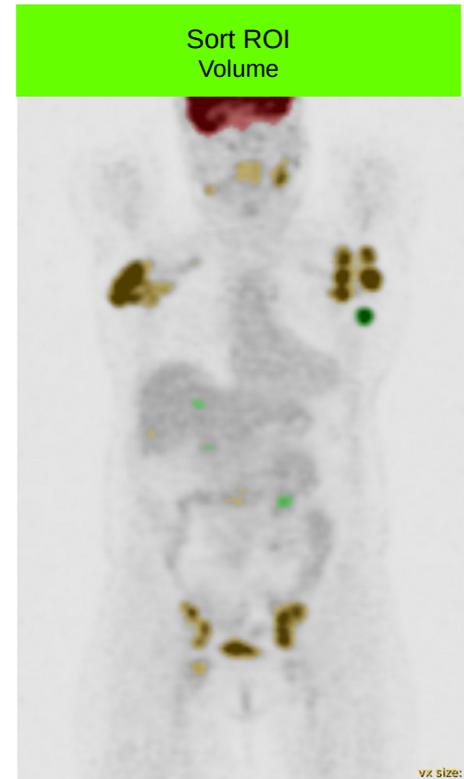
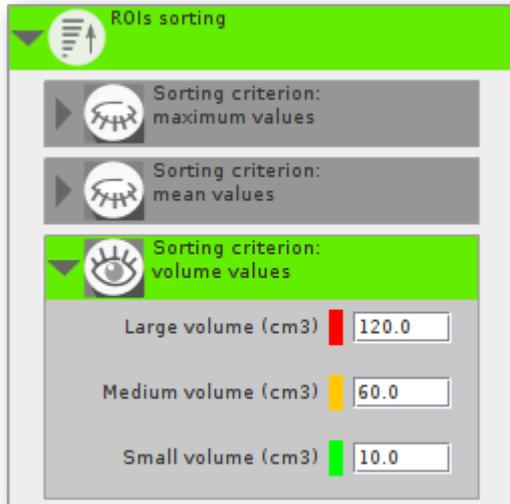
# User guide

MTV protocol

— LIFEx —

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.





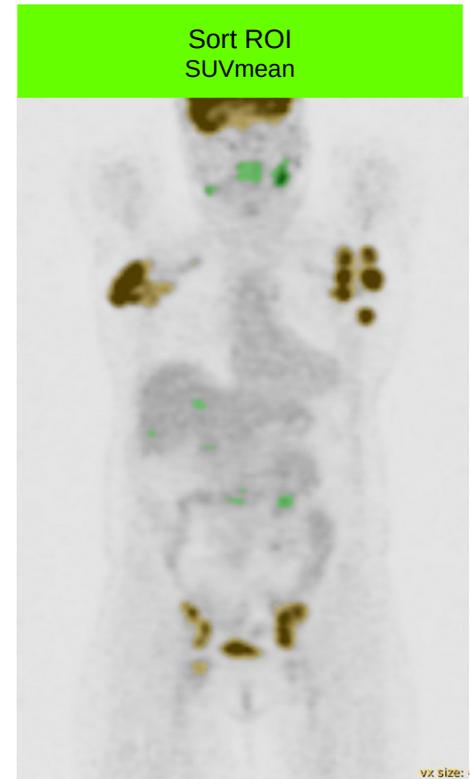
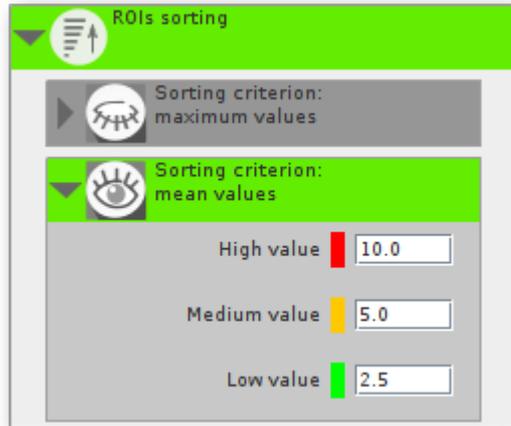
# User guide

MTV protocol

— LIFEx —

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.





# User guide

MTV protocol

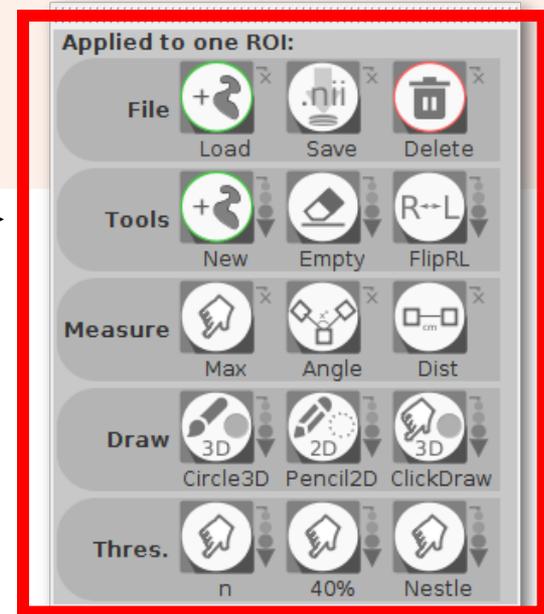
— LIFEx —

## ROI manipulation

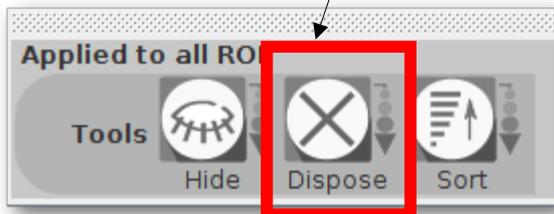
You can manipulate the segmentation results (ROIs) to refine your results:

- 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

1 →



4

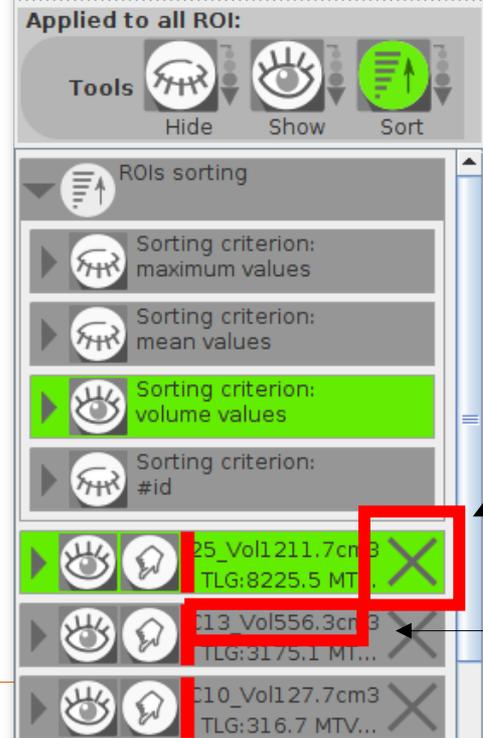


5



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

Read the tutorial: [How to draw regions with LIFEx ?](#)



2

3



# User guide

MTV protocol

— LIFEx —

## Look at the MTV results

**MTV**  
Metabolic Tumor Volume

**Step1: Init thresholds**

- mandatory thresholds
- applied to all ROIs:
- Absolute SUV threshold =SUV (3.0<>99999.0)
- Pruning volume =(0.50<>999999.00)cm3

**Step2: Setting thres...**

- applied to ROIs with open eyes:
- Absolute SUV threshold =SUV (4.0<>999.0)
- SUV / liver activity ratio >=1.5
- % of SUVmax threshold =41.0%
- Adaptive threshold beta=0.300
- at least n of positive thresholds:
- 1/4 or 2/4 or 3/4 or 4/4

**Step3: Volume refine...**

- applied to all ROIs:
- Pruning volume =(0.50<>999999.00)cm3

**Run Results**

TLG:14541 SUV\*mL  
STLG:264 SUV\*mL/Kg  
TMTV:1981 mL  
STMTV:36.0 mL/Kg

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



# User guide

MTV protocol

— LIFEx —

## Look at the MTV results

MTV  
Metabolic Tumor Volume

Step1: Init thresholds

- mandatory thresholds
- applied to all ROIs:
- Absolute SUV threshold = SUV (2.2 --- 99999.0)
- Pruning volume = (0.50 --- 999999.00) cm3

Step2: Setting thresholds

- applied to ROIs with open eyes:
- 100% Absolute SUV threshold = SUV (2.2 --- 999.0)
- 98% SUV / liver activity ratio  $\geq 1.5$
- 56% % of SUVmax threshold = 41.0%
- 92% Adaptive threshold beta=0.300
- at least n of positive thresholds:
- or or or

Step3: Volume refinement

- applied to all ROIs:
- Pruning volume = (0.60 --- 999999.00) cm3

Run / Results

Run Save results Save ROIs ROIs

TLG: 0 SUV\*mL  
STLG: 0 SUV\*mL/Kg  
TMTV: 0 mL  
STMTV: 0.0 mL/Kg

Interpretation of the percentages shown at the left of the threshold 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 adaptive 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](mailto:contact@lifexsoft.org)