IMAGING RESEARCH LABORATORY
UNIVERSITY of WASHINGTON
Department of Radiology

Quantitative Imaging Biomarkers Alliance RSNA

# PET/CT Digital Reference Object Threshold Analysis

Larry Pierce[1], Brian Elston[1], David Clunie[3], Dennis Nelson[2], Paul Kinahan[1],

[1] University of Washington - Department of Radiology
[2] MIM Software
[3] PixelMed

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## 1 Project Description

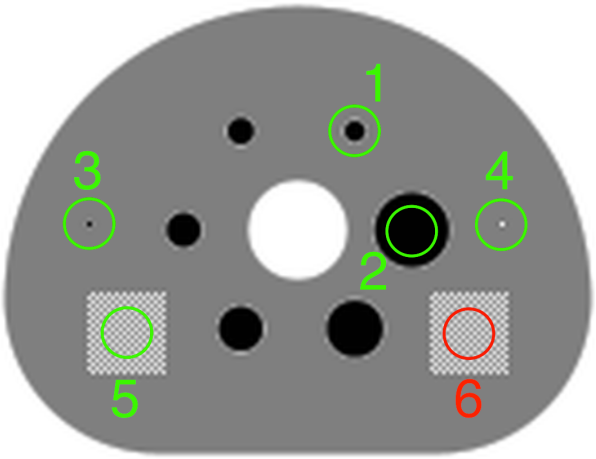
The Digital Reference Object was downloaded and tested on twenty-two different workstations with twenty-two different software packages (including different versions of the same software). The software tested represents thirteen unique software vendors.

Each user was asked to complete a table similar to that shown in Figure 1. For each of the twenty-four measurements in the table, we show the data returned in a scatterplot-style format. The site numbers in Figures 5 through 28 are randomized so that no two figures have the same ordering of the sites.

For each of the twenty-four measurements, we computed the theoretical measurement as a function of the center of the ROI as well as the diameter of the ROI. These measurements were generated using the center-inclusion voxel method as well as the partial-voxel method described below for computation of metrics.

Each theoretical ROI was defined as a circle (a sphere for ROI 6) and the center was perturbed ±3 millimeters in one millimeter increments, creating a lattice of center points in x and y (and z for ROI 6). For each center position, the diameter of the ROI was perturbed ±3 millimeters in 0.5 millimeter increments.

We then show the results side-by-side in Figures 5 through 24 as well as proposed error thresholds.




| ROI | Max | Min | Mean | STD |
|---|---|---|---|---|
| ROI 1 | | | | |
| ROI 2 | | | | |
| ROI 3 | | | | |
| ROI 4 | | | | |
| ROI 5 | | | | |
| ROI 6 | | | | |

Figure 1: Users of the DRO were asked to fill out this table, recording SUV metrics for each of the six ROIs illustrated at the left. The green ROIs represent 2D circular and red represents 3D spherical ROIs.

# 2 ROI Definitions

## 2.1 Binary Center Inclusion

We include a voxel in the ROI if the center of the voxel is within the theoretically defined sphere. Voxels are weighted zero or one, indicating no partial voxels. This is illustrated in Figure 2.

To define the Max, Min, Mean, and Standard Deviation for the ROI, each measurement was performed on the set of voxels defined to be within the ROI.

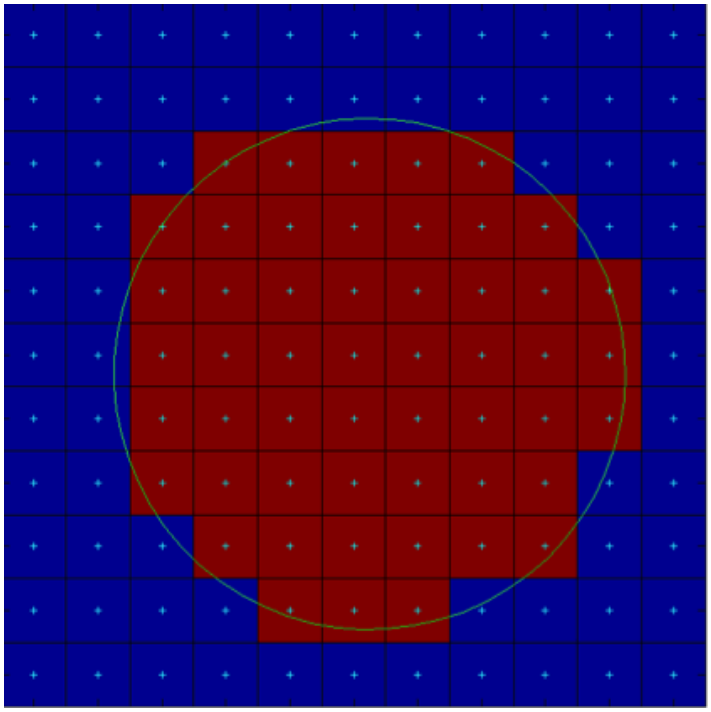


Figure 2: A theoretically defined circular region (in green). Voxels are included in the ROI if the center of the voxel is within the theoretical region. Voxels included in the ROI are shown in red, those not in the ROI are shown in blue. Voxel centers are illustrated in light blue.

## 2.2 Partial Voxel Computation

We also computed the theoretical ROI values by using a partial voxel method. In this computation, each pixel in the test slice was sub-divided into $10 \times 10$ equal sub-pixels and the Binary Center Inclusion method described above was performed on those sub-pixels.

For ROI 6 (the 3D sphere), the voxels were divided into $10 \times 10 \times 10$ sub-voxels and the binary center inclusion method was performed on the sub-voxels.

In both cases, the Max, Min, Mean and Standard Deviation of the ROI was performed on the set of sub-voxels defined by the Binary Center Inclusion method.

# 3 NOTES

1. The consensus of the QIBA group in developing the FDG profile has been to state "Shall output results with at least two decimal places" [ QIBA Profile: FDG-PET/CT as an Imaging Biomarker Measuring Response to Cancer Therapy *March 9, 2013* Version for Public Comment 1.03 – section 4.4.1 Region of Interest (ROI) definition – ROI Output Statistics). http://qibawiki.rsna.org/index.php?title=FDG-PET_tech_ctt ]
2. There is no way of knowing if the user-reported values with errors are due to mis-reporting from the software being tested or if the error comes from the user typing in the wrong value into the excel spreadsheet. Determining the source of any errors is beyond the scope of this project.

# 4 Results

In Figures 5 through 28, the left column figures show the results of the theoretical computation (performed in matlab) of the ROI measurements together with the reported results from the twenty-two users.

For each metric recorded in the Table, we show the theoretical measurements in the image on the left. The measurements computed for the Binary Center Inclusion ROI definition is shown as blue circles and those for the Partial Voxel ROI definition are shown as magenta crosses.

The "true" theoretical ROI value is shown as a green line, and two red dotted lines show proposed thresholds for acceptable measurements. In many cases, these thresholds are arbitrarily close the the "true" measurement and we chose three decimal places of precision for this tolerance to reflect the two decimal places proposed by the QIBA report.

An additional buffer zone of 50% of the proposed threshold range has also been added to both the upper and lower thresholds. These bounds are illustrated with magenta dotted lines.

The figures in the right column show the user-reported ROI measurements as blue circles. The proposed thresholds and "true" values (dotted red and solid green lines) from the figure on the left are shown along with the user reported data.

**The ordering of the site numbers in each figure is randomized such that no two figures have the same ordering of the sites.**

Furthermore, we report the results from each site in the color-coded grid shown in Figure **??**. Each column represents an individual report, and each row is an SUV measurement from the report. The numerical values have been omitted, but each field is shown in blue if it is within the recommended thresholds, yellow if the value is outside the thresholds yet still within additional the 50% range and red if it is outside the additional 50% range. The color-coding scheme is illustrated in Figure 4.

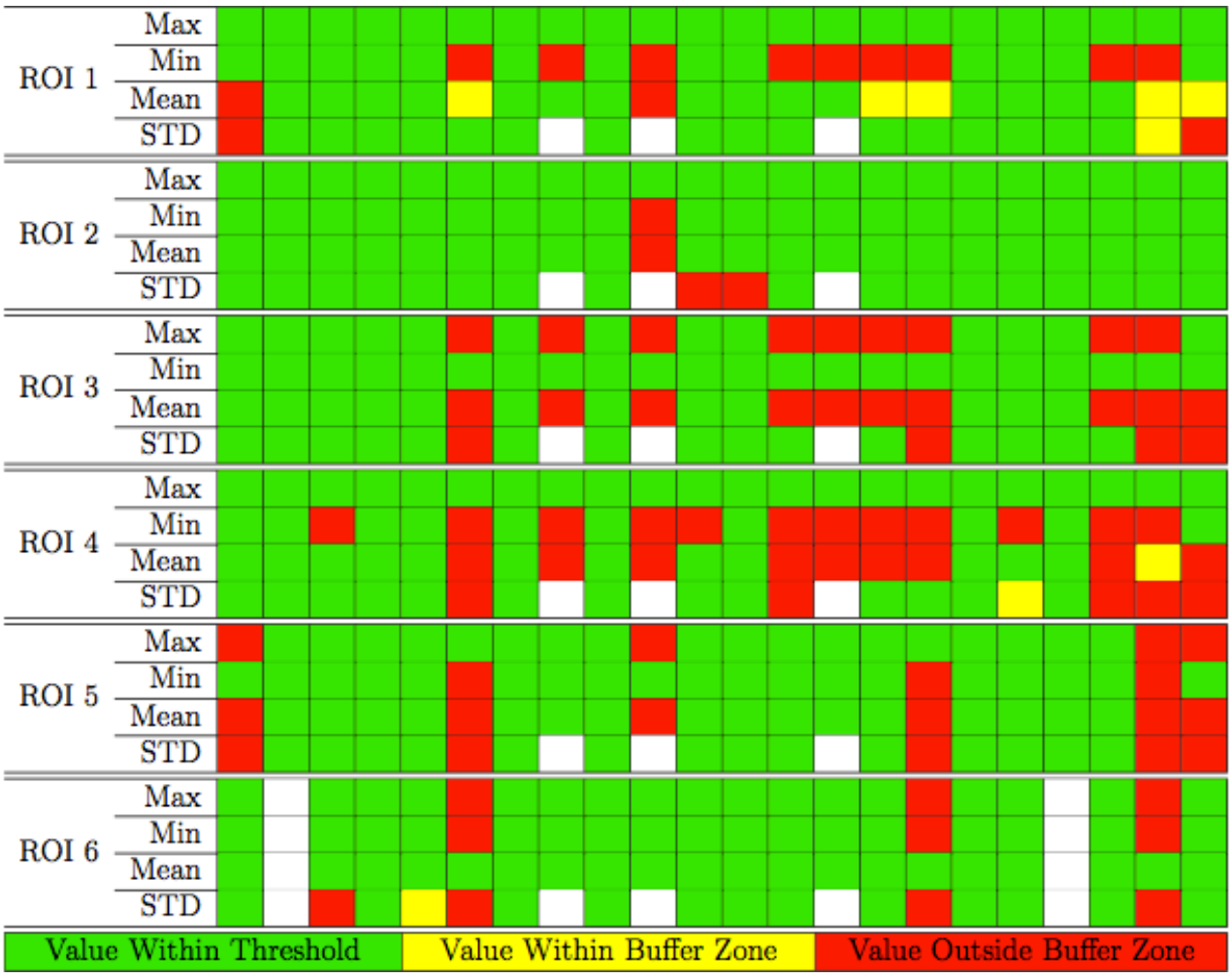



Figure 3: Results from 22 reporting sites. Each column represent one report. Each row is a reported value from the report. The color of each cell is assigned according to Figure 4. Blue – within proposed thresholds ; Yellow – within 150% of proposed threshold range ; Red – beyond 150% of the proposed threshold range ; Orange – Data not provided.

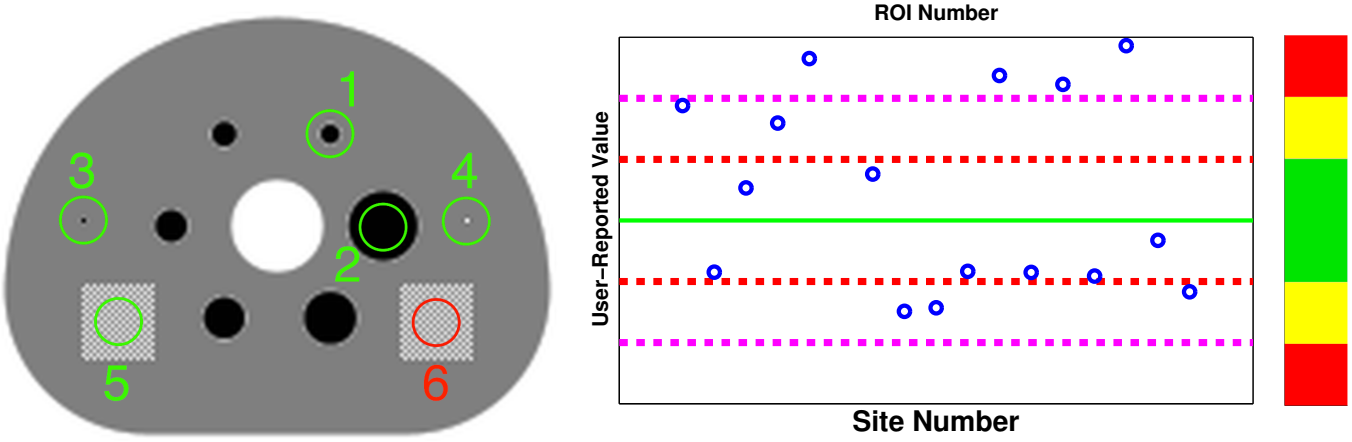
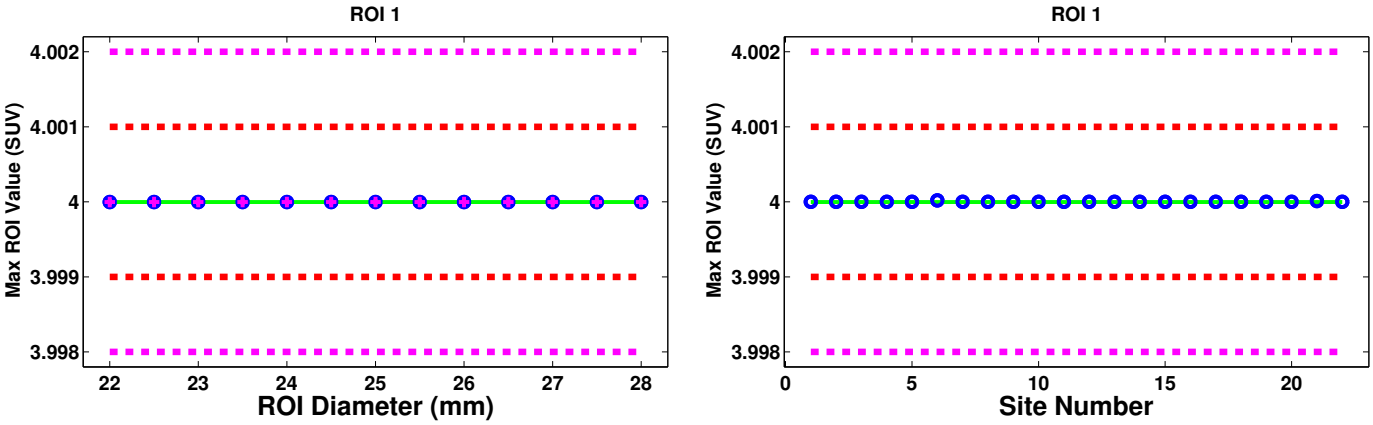



Figure 4: The coloring scheme for the cells in Figure 3 is linked to the user-reported values in Figures 5 through 28 according to the color scale at the right. Blue circles represent the reported value in the cell and the dotted red lines indicate the proposed threshold values. The dotted magenta lines are a 50% percent buffer zone beyond the threshold values.

# ROI 1 Results




(a) Theoretical $SUV_{max}$ versus ROI 1 diameter

(b) User Reported $SUV_{max}$ from ROI 1

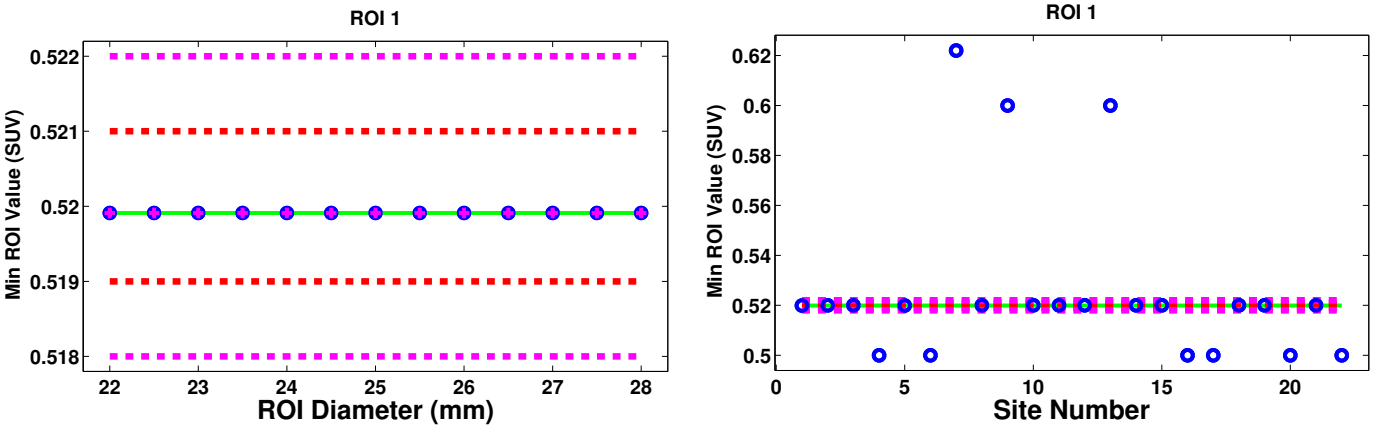
Figure 5: Theoretical and Reported results for the $SUV_{max}$ for ROI 1

In Figure 5, we see the results for the $SUV_{max}$ for ROI 1. The theoretical $SUV_{max}$ values are independent of the center position or the diameter of the ROI.

The theoretical $SUV_{max}$ for ROI 1 should be 4.000, the SUV value within the smallest sphere.

Most users reported an $SUV_{max}$ of 4, 4.0, or 4.00 , however one user reported a value of 4.000019 and another reported a value of 4.0000095. These values are not reflected on the y-axis of the user-reported values in Figure 5.

We propose that acceptable reported values for $SUV_{max}$ for ROI 1 be within 3.999 and 4.001.




(a) Theoretical $SUV_{min}$ versus ROI 1 diameter

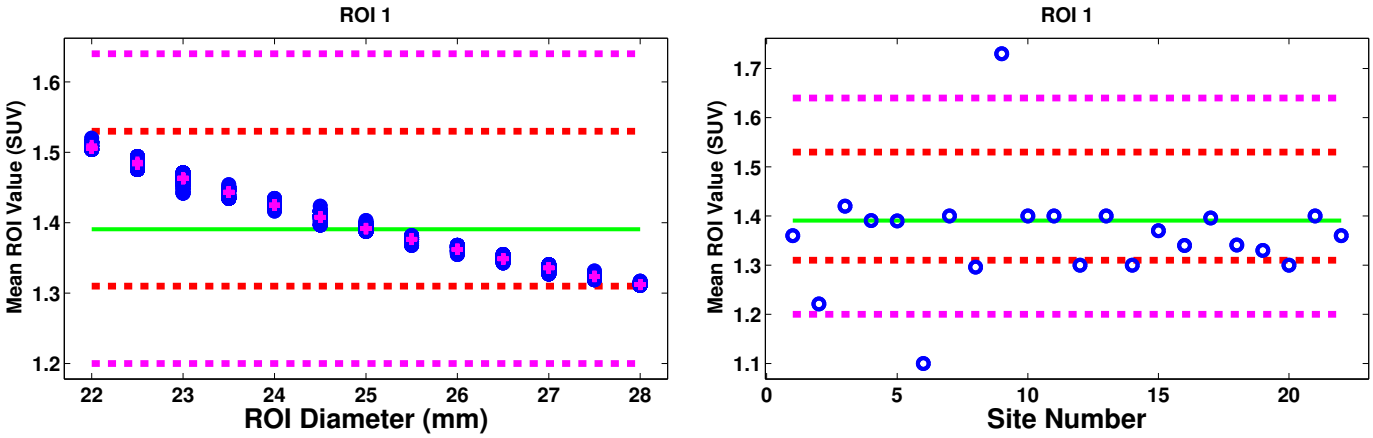
(b) User Reported $SUV_{min}$ from ROI 1

Figure 6: Theoretical and Reported results for the $SUV_{min}$ for ROI 1 (See also Figure 29)

In Figure 6, we see the results for the $SUV_{min}$ for ROI 1. The theoretical $SUV_{min}$ values are independent of the center position or the diameter of the ROI.

The theoretical $SUV_{min}$ for ROI 1 should be 0.520, a voxel inside the wall of the smallest sphere that includes a partial volume effect.

We propose that acceptable reported values for $SUV_{min}$ for ROI 1 be within 0.519 and 0.521.




(a) Theoretical $\text{SUV}_{mean}$ versus ROI 1 diameter

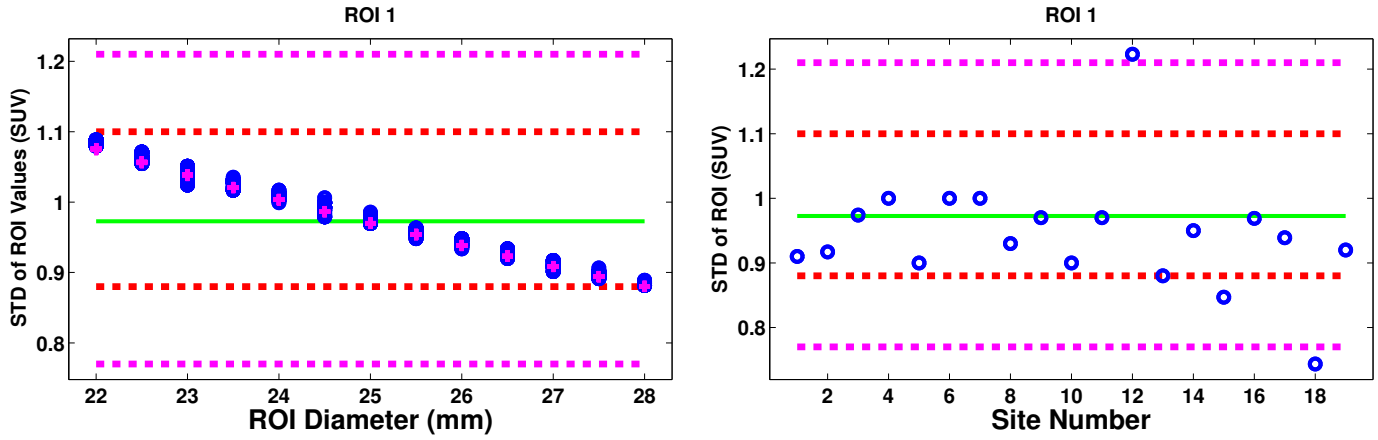
(b) User Reported $\text{SUV}_{mean}$ from ROI 1

Figure 7: Theoretical and Reported results for the $\text{SUV}_{mean}$ for ROI 1

In Figure 7, we see the results for the $\text{SUV}_{mean}$ for ROI 1. Note that as the diameter of a theoretical ROI increases, more background values are included within the ROI, causing the mean value to decrease.

The theoretical $\text{SUV}_{mean}$ for ROI 1 should be 1.391, calculated from the center-inclusion ROI of a theoretical circle with diameter 25 mm and whose center coincides with analytically-defined center of the smallest sphere.

We propose that acceptable reported values for $\text{SUV}_{mean}$ for ROI 1 be within 1.310 and 1.530.




(a) Theoretical Standard Deviation of SUV values in ROI 1 versus ROI 1 diameter

(b) User Reported Standard Deviation of SUV values in ROI 1

Figure 8: Theoretical and Reported results for the standard deviation of ROI 1

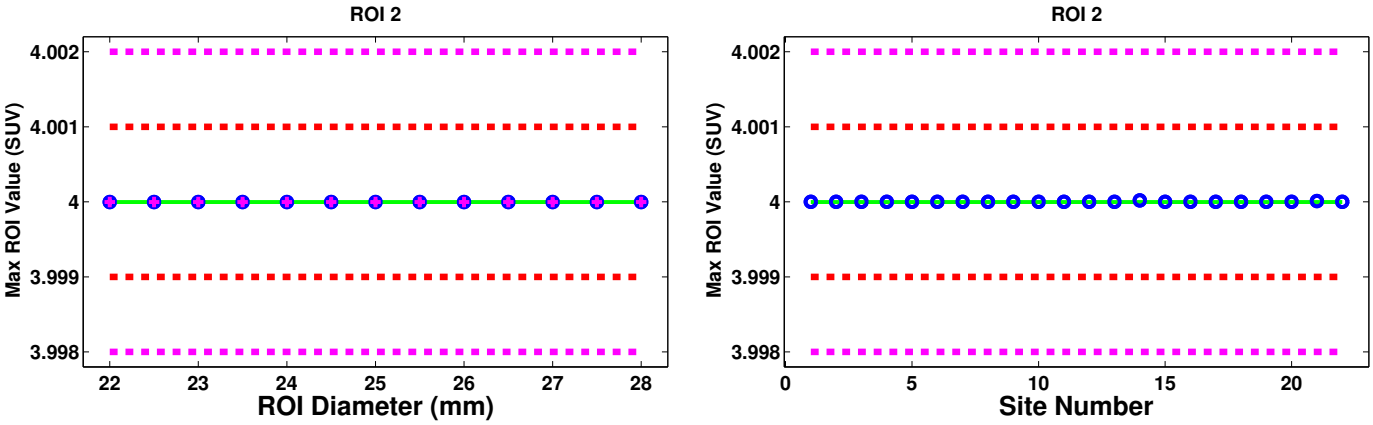
In Figure 8, we see the results for the standard deviation of the voxels in ROI 1. Note that as the diameter of a theoretical ROI increases, more background values are included within the ROI, resulting in a lower standard deviation within the ROI.

The theoretical standard deviation for ROI 1 should be 0.973, calculated from the center-inclusion ROI of a theoretical circle with diameter 25 mm and whose center coincides with analytically-defined center of the smallest sphere.

Three users did not report a standard deviation for ROI 1.

We propose that acceptable reported values for $\text{SUV}_{STD}$ for ROI 1 be within 0.880 and 1.100.

# ROI 2 Results




(a) Theoretical $SUV_{max}$ versus ROI 2 diameter

(b) User Reported $SUV_{max}$ from ROI 2

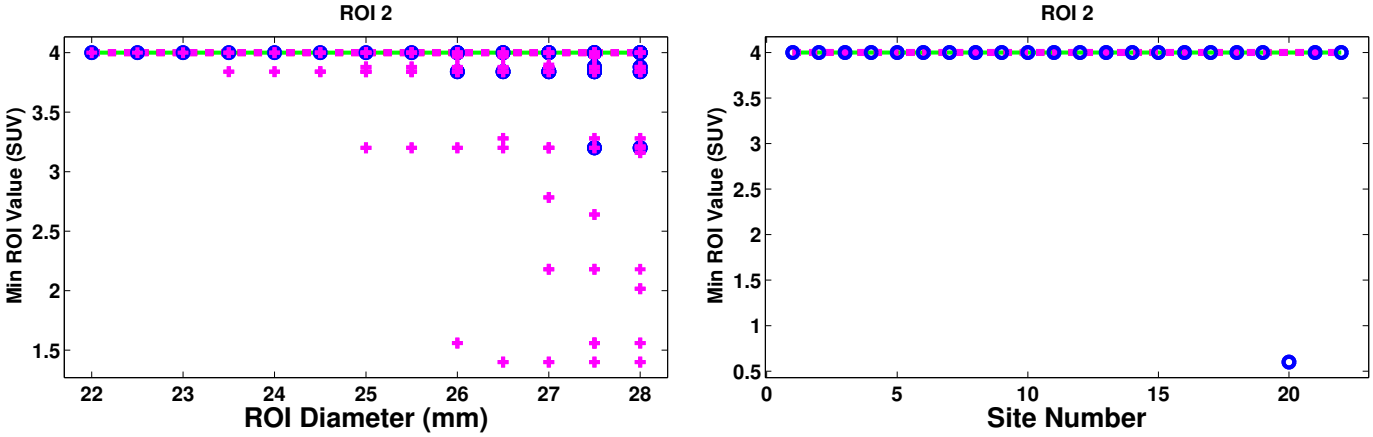
Figure 9: Theoretical and Reported results for the $SUV_{max}$ for ROI 2

In Figure 9, we see the results for the $SUV_{max}$ for ROI 2. The theoretical $SUV_{max}$ is independent of the center position or the diameter of the ROI.

The theoretical $SUV_{max}$ for ROI 2 should be 4.000, the SUV value within the largest sphere.

Most users reported an $SUV_{max}$ of 4, 4.0, or 4.00 , however one user reported a value of 4.000019 and another reported a value of 4.0000095. These values are not reflected on the y-axis of the user-reported values in Figure 9.

We propose that acceptable reported values for $SUV_{max}$ for ROI 2 be within 3.999 and 4.001.




(a) Theoretical $SUV_{min}$ versus ROI 2 diameter

(b) User Reported $SUV_{min}$ from ROI 2

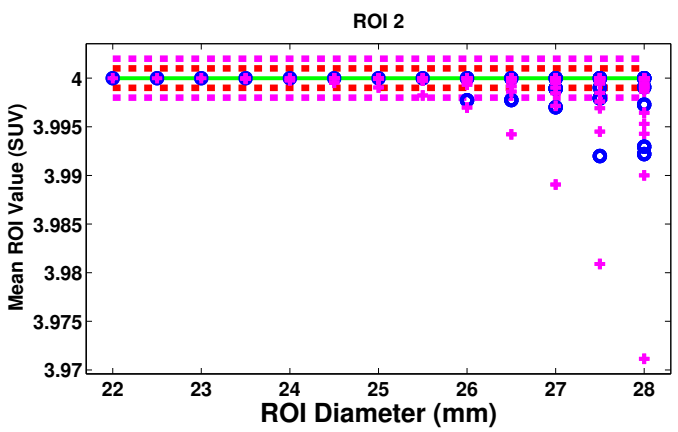
Figure 10: Theoretical and Reported results for the $SUV_{min}$ for ROI 2 (See also Figure 30)

In Figure 10, we see the results for the $SUV_{min}$ for ROI 2. As the diameter of the theoretical ROI becomes very large, some voxels at the edge of the sphere are included, showing some $SUV_{min}$ values below 4.00.

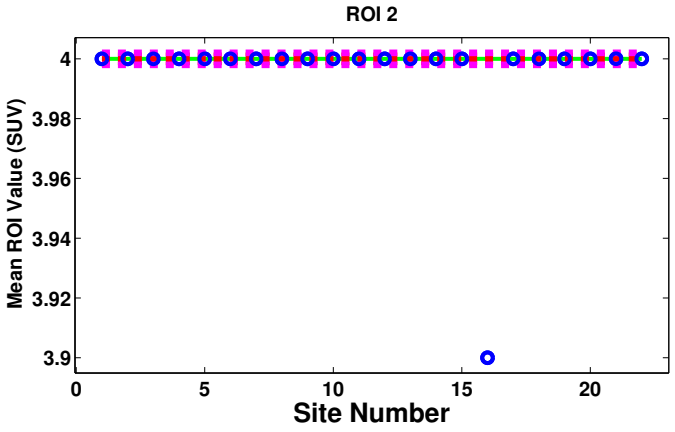
The theoretical $SUV_{min}$ for ROI 2 should be 4.000, the SUV value within the largest sphere.

Most users reported values of 4.00 (except those reporting more than six decimal places). One anomalous user value of 0.6 was given.

We propose that acceptable reported values for $SUV_{min}$ for ROI 2 be within 3.999 and 4.001.




(a) Theoretical $\text{SUV}_{mean}$ versus ROI 2 diameter




(b) User Reported $\text{SUV}_{mean}$ from ROI 2

Figure 11: Theoretical and Reported results for the $\text{SUV}_{mean}$ for ROI 2 (See also Figure 31)

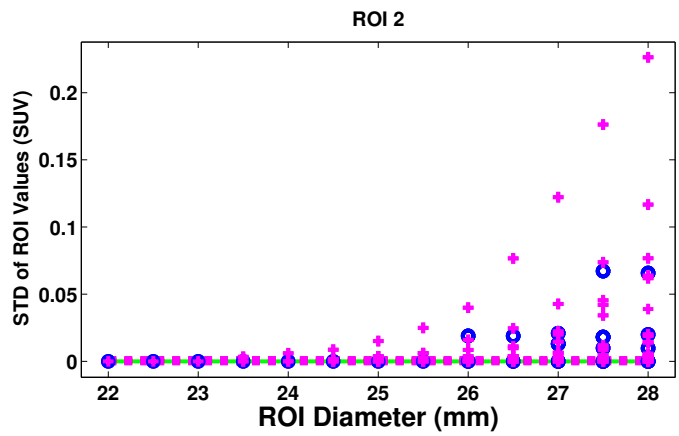
In Figure 11, we see the results for the $\text{SUV}_{mean}$ for ROI 2. As the diameter of the theoretical ROI becomes very large, some voxels at the edge of the sphere are included, reducing the $\text{SUV}_{mean}$ value.

The theoretical $\text{SUV}_{mean}$ for ROI 2 should be 4.000, as all voxels within the sphere have the same value.

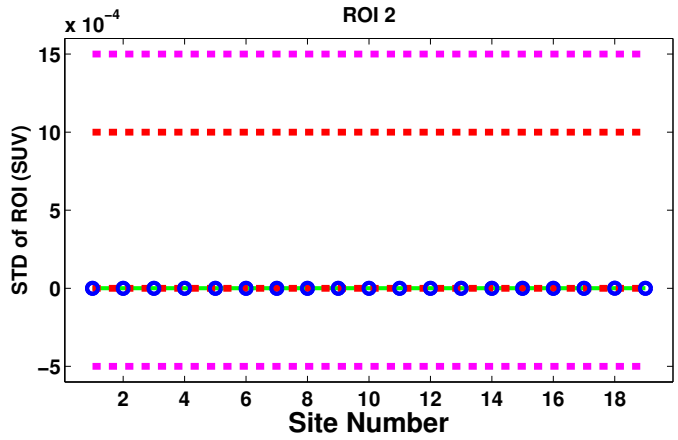
Most users reported a $\text{SUV}_{mean}$ of 4.00 (except those reporting more than six decimal places).

One anomalous user-reported value of 3.9. This is the same user reported 0.6 for the $\text{SUV}_{min}$ for ROI 2.

We propose that acceptable reported values for $\text{SUV}_{mean}$ for ROI 2 be within 3.999 and 4.001.




(a) Theoretical Standard Deviation of SUV values in ROI 2 versus ROI 2 diameter




(b) User Reported Standard Deviation of SUV values in ROI 2

Figure 12: Theoretical and Reported results for the standard deviation of ROI 1

In Figure 12, we see the results for the standard deviation of the voxels in ROI 2. As the diameter of the theoretical ROI becomes very large, some voxels at the edge of the sphere are included, increasing the standard deviation.

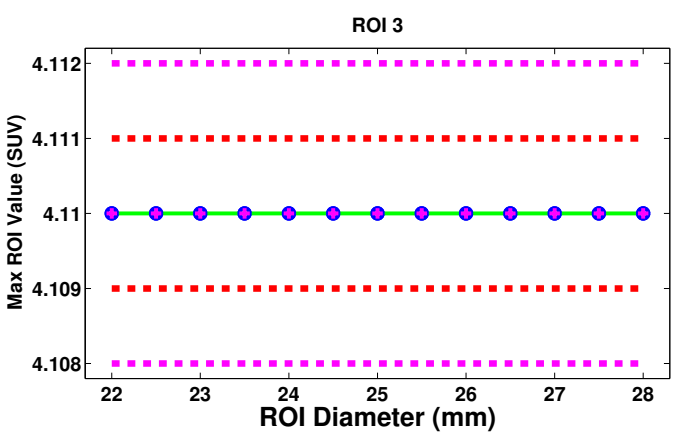
The theoretical standard deviation for ROI 2 should be 0.000, as all voxels in the sphere have the same value.

Most users reported 0.00 for the standard deviation of ROI 2, with one anomalous value of 2.6077E-07. This was the user that reported seven decimal places for all reported values. (The user that reported six decimal places for all values reported a value of 0.00.)

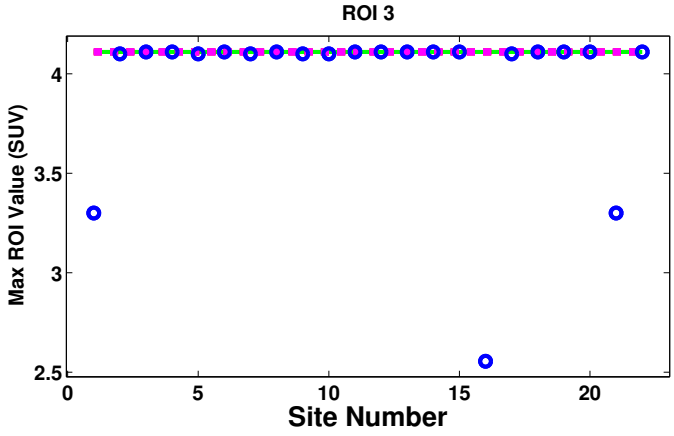
Three users did not report a standard deviation for ROI 2. Two users reported NaN (not-a-number) for the standard deviation of ROI 2.

We propose that acceptable reported values for $\text{SUV}_{STD}$ for ROI 2 be within 0.000 and 0.001.

# ROI 3 Results




(a) Theoretical $SUV_{max}$ versus ROI 3 diameter




(b) User Reported $SUV_{max}$ from ROI 3

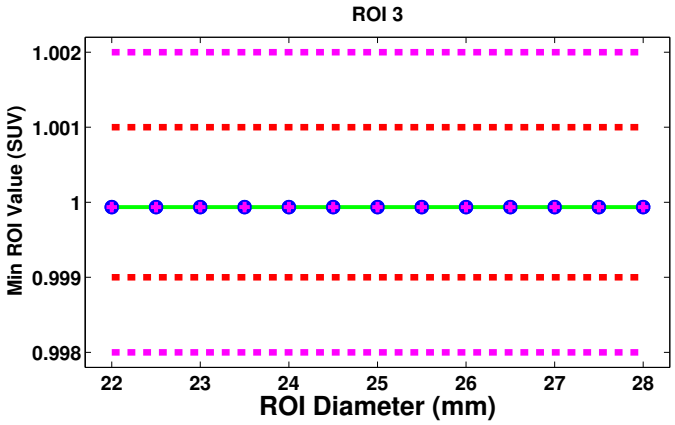
Figure 13: Theoretical and Reported results for the $SUV_{max}$ for ROI 3 (See also Figure 32)

In Figure 13, we see the results for the $SUV_{max}$ for ROI 3. The theoretical $SUV_{max}$ is independent of the center position or the diameter of the ROI.

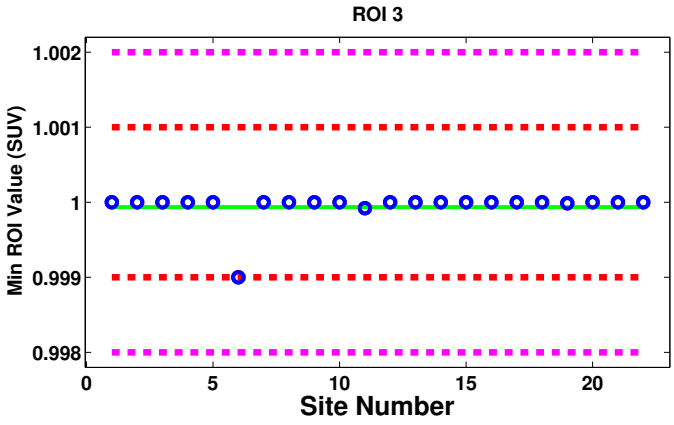
The theoretical $SUV_{max}$ for ROI 3 should be 4.110, the value of the hot test voxel.

Many users reported the $SUV_{max}$ for ROI 3 as 4.11 or 4.1, with anomalous values of 2.555, 3.3, 4.1099997, and 4.110001.

We propose that acceptable reported values for $SUV_{max}$ for ROI 3 be within 4.109 and 4.111.




(a) Theoretical $SUV_{min}$ versus ROI 3 diameter




(b) User Reported $SUV_{min}$ from ROI 3

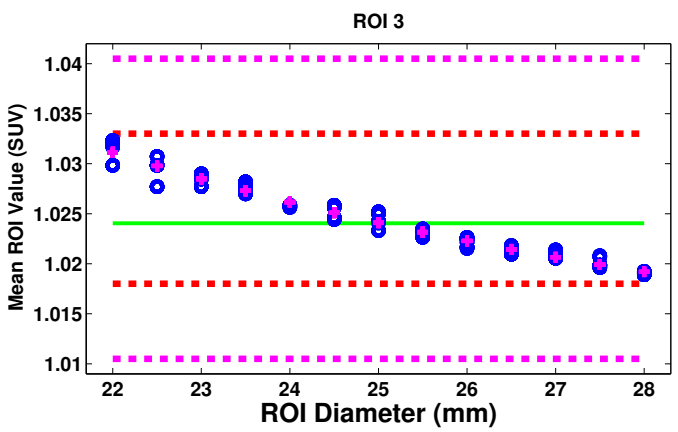
Figure 14: Theoretical and Reported results for the $SUV_{min}$ for ROI 3

In Figure 14, we see the results for the $SUV_{min}$ for ROI 3. The theoretical $SUV_{min}$ values are independent of the center position or the diameter of the ROI.

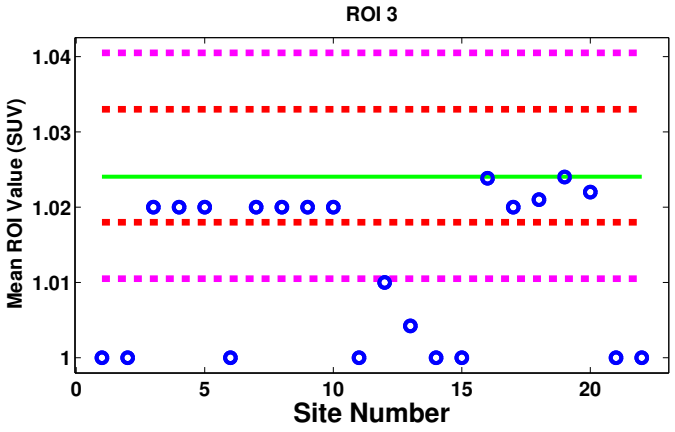
The theoretical $SUV_{min}$ for ROI 3 should be 1.000, the value of the background.

Most users reported an $SUV_{min}$ of 1.00, with anomalous values of 0.999, 0.999922, and 0.99998724.

We propose that acceptable reported values for $SUV_{min}$ for ROI 3 be within 0.999 and 1.001.




(a) Theoretical $\text{SUV}_{mean}$ versus ROI 3 diameter




(b) User Reported $\text{SUV}_{mean}$ from ROI 3

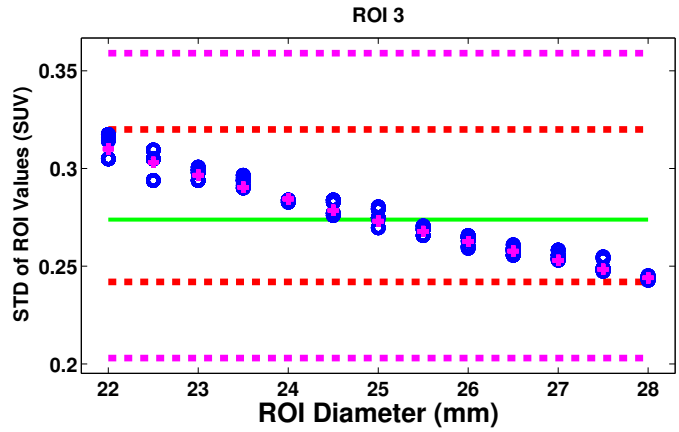
Figure 15: Theoretical and Reported results for the $\text{SUV}_{mean}$ for ROI 3

In Figure 15, we see the results for the $\text{SUV}_{mean}$ for ROI 3. As the diameter of the theoretical ROI becomes larger, more background voxels are included, thus reducing the $\text{SUV}_{mean}$.

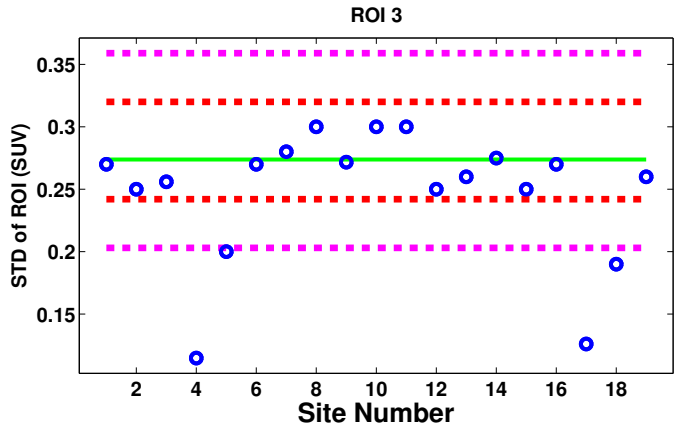
The theoretical $\text{SUV}_{mean}$ for ROI 3 should be 1.024, calculated from the center-inclusion ROI of a theoretical circle with diameter of 25 mm and whose center coincides with the center of the hot test voxel.

The user-reported values for the $\text{SUV}_{mean}$ for ROI 3 are varied as shown in Figure 15.

We propose that acceptable reported values for $\text{SUV}_{mean}$ for ROI 3 be within 1.018 and 1.033.




(a) Theoretical Standard Deviation of SUV values in ROI 3 versus ROI 3 diameter




(b) User Reported Standard Deviation of SUV values in ROI 3

Figure 16: Theoretical and Reported results for the standard deviation of ROI 3

In Figure 16, we see the results for the standard deviation of the voxels in ROI 3. As the diameter of the theoretical ROI becomes larger, more background voxels are included, thus decreasing the standard deviation.

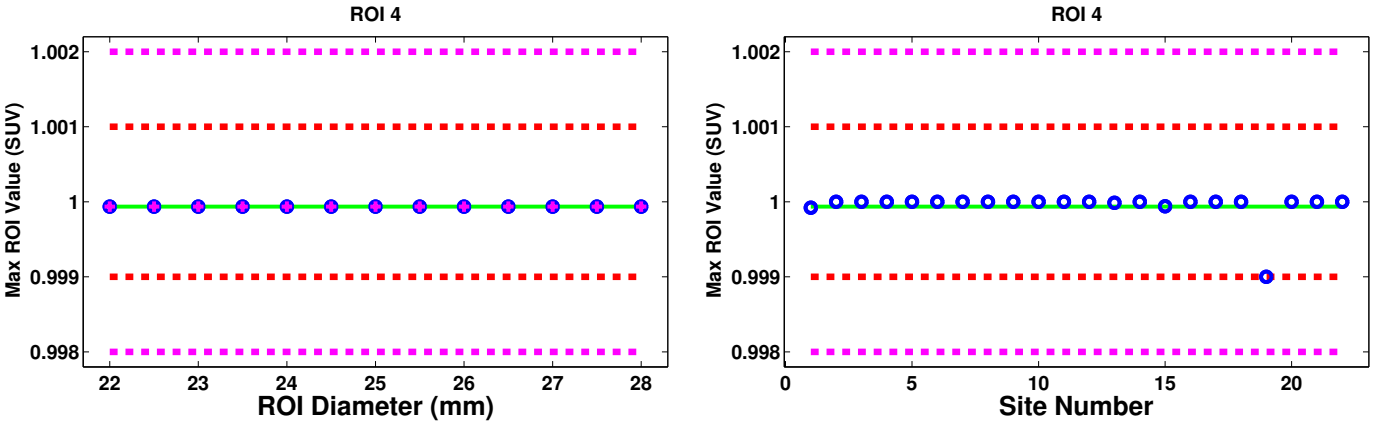
The theoretical standard deviation for ROI 3 should be 0.274, calculated from the center-inclusion ROI of a theoretical circle with diameter of 25 mm and whose center coincides with the center of the hot test voxel.

The user-reported standard deviation values for ROI 3 ranged from 0.11473396 to 0.3.

Three users did not report a standard deviation for ROI 3.

We propose that acceptable reported values for $\text{SUV}_{STD}$ for ROI 3 be within 0.242 and 0.320.

# ROI 4 Results




(a) Theoretical $SUV_{max}$ versus ROI 4 diameter

(b) User Reported $SUV_{max}$ from ROI 4

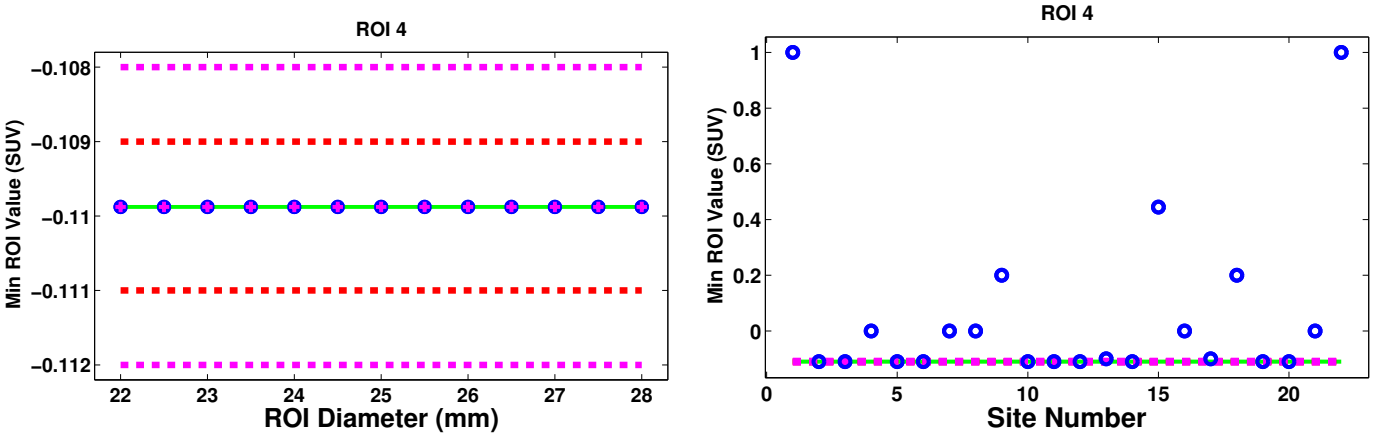
Figure 17: Theoretical and Reported results for the $SUV_{max}$ for ROI 4

In Figure 17, we see the results for the $SUV_{max}$ for ROI 4. The theoretical $SUV_{max}$ values are independent of the center position or the diameter of the ROI.

The theoretical $SUV_{max}$ for ROI 4 should be 1.000, the SUV value of the background.

User-reported $SUV_{max}$ values for ROI 4 range from 0.999 to 1.00.

We propose that acceptable reported values for $SUV_{max}$ for ROI 4 be within 0.999 and 1.001.




(a) Theoretical $SUV_{min}$ versus ROI 4 diameter

(b) User Reported $SUV_{min}$ from ROI 4

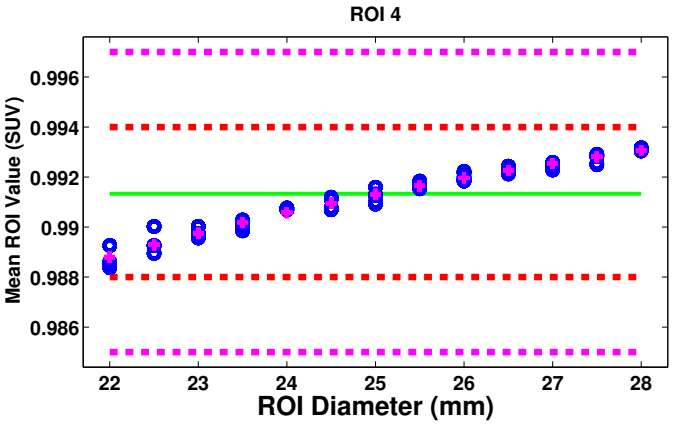
Figure 18: Theoretical and Reported results for the $SUV_{min}$ for ROI 4 (See also Figure 33)

In Figure 18, we see the results for the $SUV_{min}$ for ROI 4. The theoretical $SUV_{min}$ values are independent of the center position or the diameter of the ROI.

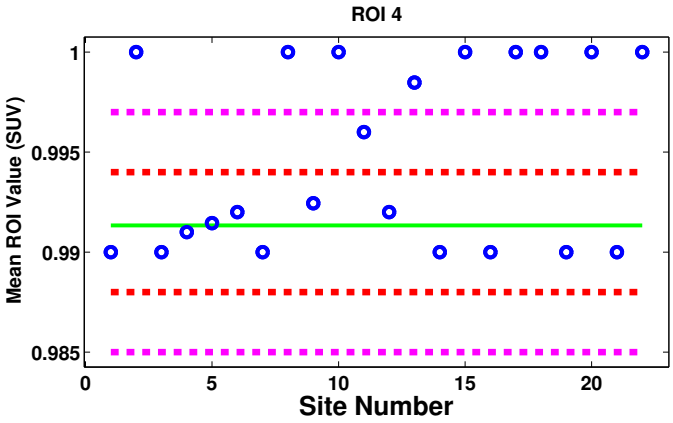
The theoretical $SUV_{min}$ for ROI 4 should be -0.110, the value of the cold test voxel.

The user-reported $SUV_{min}$ values for ROI 4 range from -0.11 to 1.00. Five users reported an $SUV_{min}$ of 0.00. Two users reported 1.00. Other anomalous values reported are 0.445, and 0.2.

We propose that acceptable reported values for $SUV_{min}$ for ROI 4 be within -0.111 and -0.109.




(a) Theoretical $\text{SUV}_{mean}$ versus ROI 4 diameter




(b) User Reported $\text{SUV}_{mean}$ from ROI 4

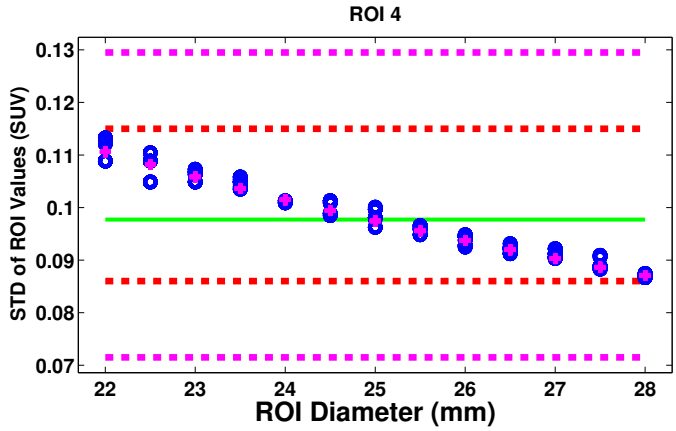
Figure 19: Theoretical and Reported results for the $\text{SUV}_{mean}$ for ROI 4

In Figure 19, we see the results for the $\text{SUV}_{mean}$ for ROI 4. Note that as the diameter of a theoretical ROI increases, more background values are included within the ROI, causing the mean value to increase.

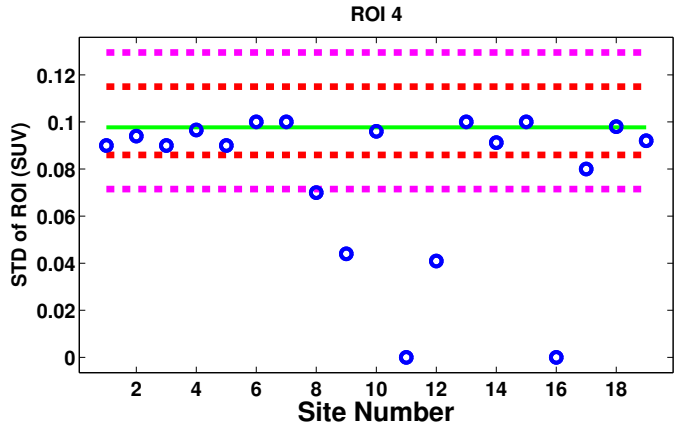
The theoretical $\text{SUV}_{mean}$ for ROI 4 should be 0.991, calculated from the center-inclusion ROI of a theoretical circle with diameter 25 mm and whose center coincides with center of the cold test voxel.

The user-reported $\text{SUV}_{mean}$ values for ROI 4 range from 0.99 to 1.00.

We propose that acceptable reported values for $\text{SUV}_{mean}$ for ROI 4 be within 0.988 and 0.994.




(a) Theoretical Standard Deviation of SUV values in ROI 4 versus ROI 4 diameter




(b) User Reported Standard Deviation of SUV values in ROI 4

Figure 20: Theoretical and Reported results for the standard deviation of ROI 4

In Figure 20, we see the results for the standard deviation of the voxels in ROI 4. Note that as the diameter of a theoretical ROI increases, more background values are included within the ROI, resulting in a lower standard deviation within the ROI.

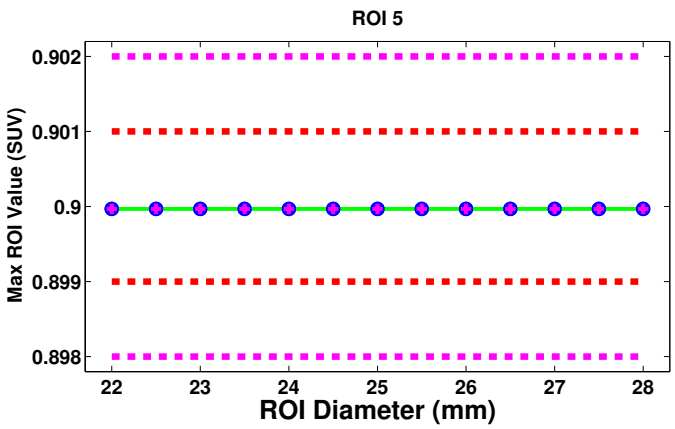
The theoretical standard deviation for ROI 4 should be 0.098, calculated from the center-inclusion ROI of a theoretical circle with diameter 25 mm and whose center coincides center of the cold test voxel.

The user-reported standard deviation values for ROI 4 range from 0.00 to 0.1.

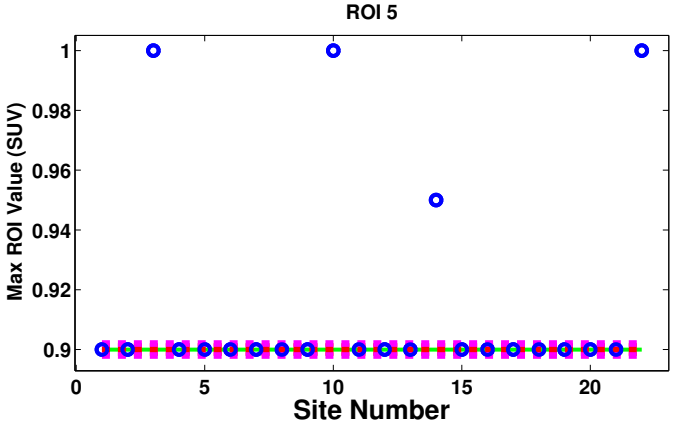
Three users did not report a standard deviation for ROI 4.

We propose that acceptable reported values for $\text{SUV}_{STD}$ for ROI 4 be within 0.086 and 0.115.

# ROI 5 Results




(a) Theoretical $SUV_{max}$ versus ROI 5 diameter




(b) User Reported $SUV_{max}$ from ROI 5

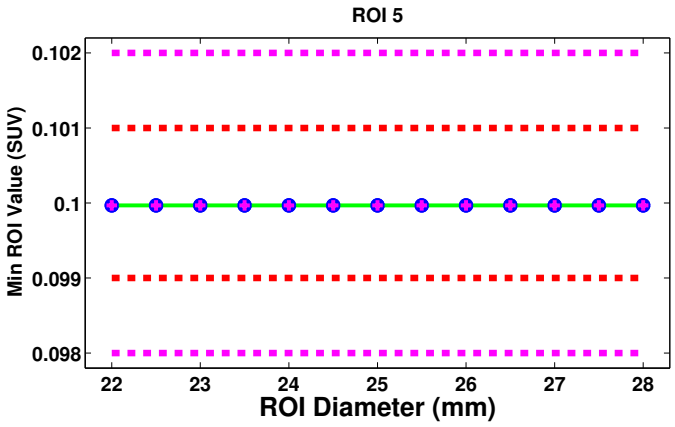
Figure 21: Theoretical and Reported results for the $SUV_{max}$ for ROI 5 (See also Figure 34)

In Figure 21, we see the results for the $SUV_{max}$ for ROI 5. The theoretical $SUV_{max}$ values are independent of the center position or the diameter of the ROI.

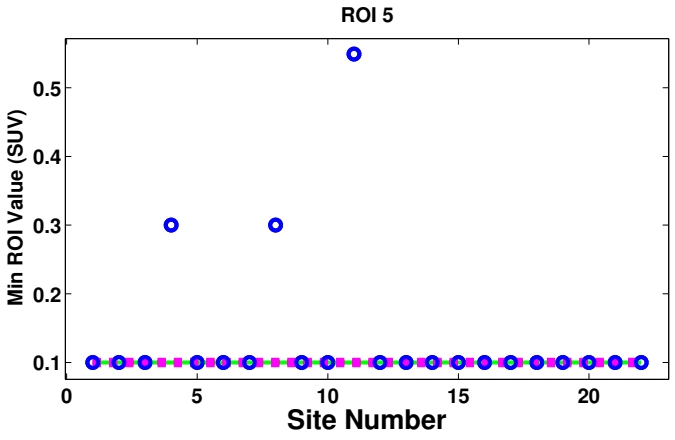
The theoretical $SUV_{max}$ for ROI 5 should be 0.900, the SUV value of the hot voxels in the checkerboard.

User-reported $SUV_{max}$ values for ROI 5 range from 0.89997 to 1.00.

We propose that acceptable reported values for $SUV_{max}$ for ROI 5 be within 0.899 and 0.901.




(a) Theoretical $SUV_{min}$ versus ROI 5 diameter




(b) User Reported $SUV_{min}$ from ROI 5

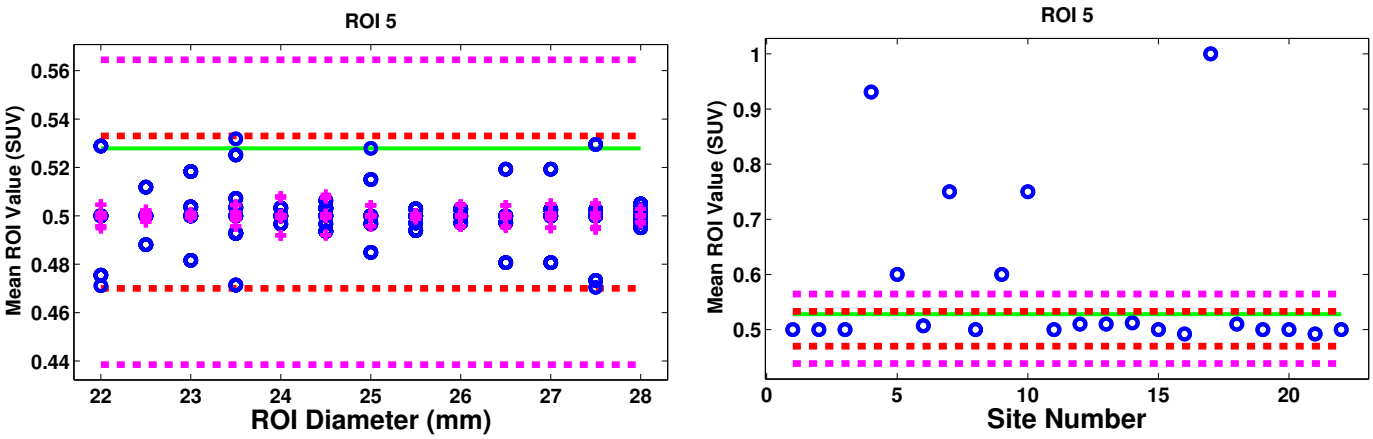
Figure 22: Theoretical and Reported results for the $SUV_{min}$ for ROI 5 (See also Figure 35)

In Figure 22, we see the results for the $SUV_{min}$ for ROI 5. The theoretical $SUV_{min}$ values are independent of the center position or the diameter of the ROI.

The theoretical $SUV_{min}$ for ROI 5 should be 0.100, the value of the cold voxels in the checkerboard.

The user-reported $SUV_{min}$ values for ROI 5 range from 0.09997 to 0.549.

We propose that acceptable reported values for $SUV_{min}$ for ROI 5 be within 0.099 and 0.101.




(a) Theoretical $\text{SUV}_{mean}$ versus ROI 5 diameter

(b) User Reported $\text{SUV}_{mean}$ from ROI 5

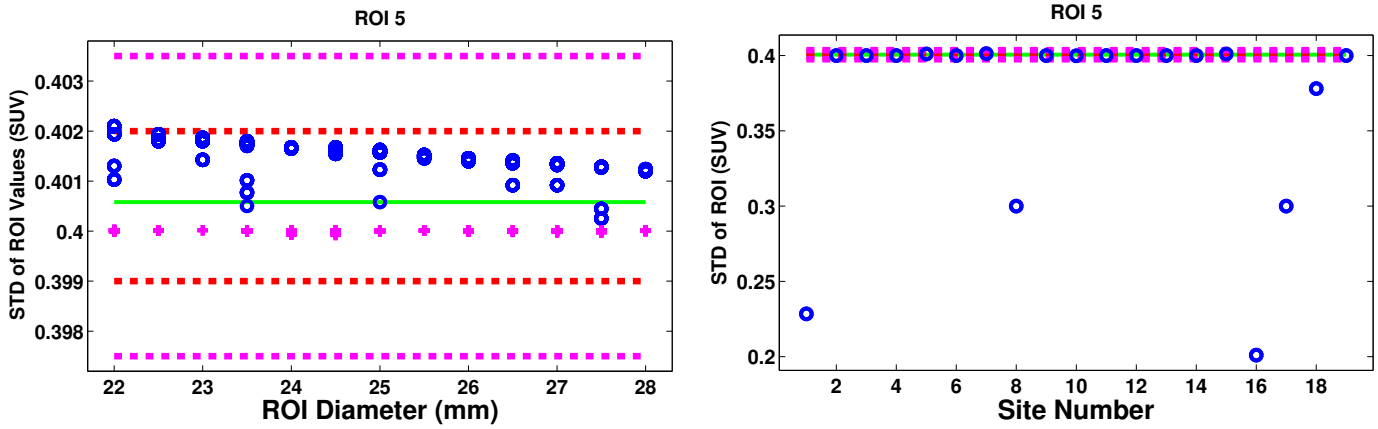
Figure 23: Theoretical and Reported results for the $\text{SUV}_{mean}$ for ROI 5

In Figure 23, we see the results for the $\text{SUV}_{mean}$ for ROI 5. Note that as the diameter and center position of a theoretical ROI changes, the ratio of cold-to-hot checkerboard voxels can change, creating a range of $\text{SUV}_{mean}$ values from 0.47 to 0.53.

The theoretical $\text{SUV}_{mean}$ for ROI 5 should be 0.500, the mean of an equal number of 0.100 valued checkerboard voxels and 0.900 valued checkerboard voxels. For a circular ROI of 25 mm diameter and centered on the center voxel of the checkerboard, matlab reports an $\text{SUV}_{mean}$ of 0.528 using the center-inclusion method. (The checkerboard has an odd number of rows and columns.)

The user-reported $\text{SUV}_{mean}$ values for ROI 5 range from 0.492 to 1.00.

We propose that acceptable reported values for $\text{SUV}_{mean}$ for ROI 5 be within 0.470 and 0.533.




(a) Theoretical Standard Deviation of SUV values in ROI 5 versus ROI 5 diameter

(b) User Reported Standard Deviation of SUV values in ROI 5

Figure 24: Theoretical and Reported results for the standard deviation of ROI 5 (See also Figure 36)

In Figure 24, we see the results for the standard deviation of the voxels in ROI 5. As the diameter and center position of a theoretical ROI change, the ratio of cold-to-hot checkerboard voxels can change, resulting in a range of standard deviation values. These values must necessarily be greater than or equal to 0.400, the theoretical value.

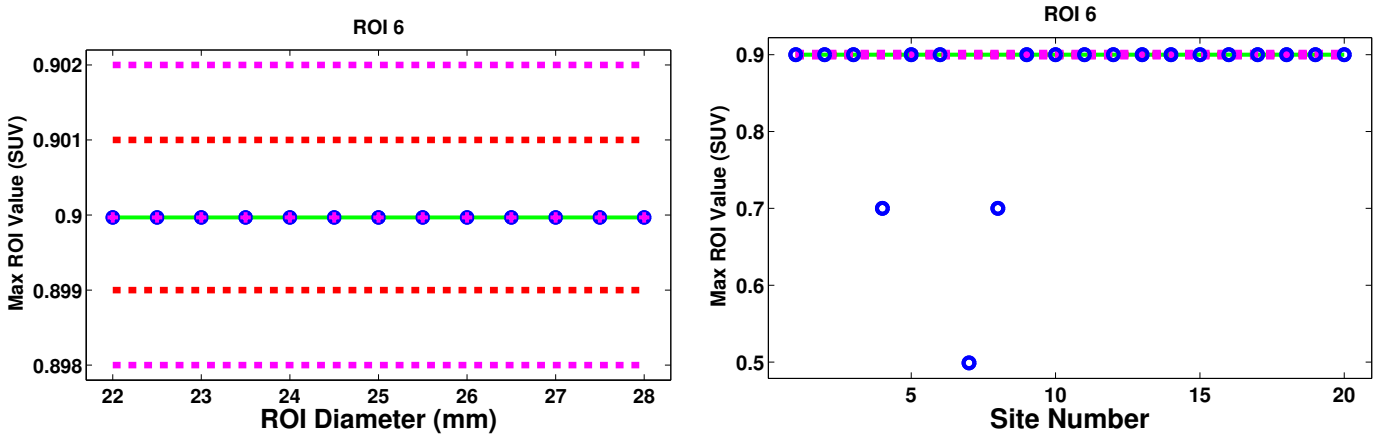
The theoretical standard deviation for ROI 5 should be 0.400, the standard deviation of an equal number of 0.100 valued checkerboard voxels and 0.900 valued checkerboard voxels. For a circular ROI of 25 mm diameter and centered on the center voxel of the checkerboard, matlab reports a standard deviation of 0.401 using the center-inclusion method.

The user-reported standard deviation values for ROI 5 range from 0.201 to 0.401. Six users reported a standard deviation less than 0.40.

Three users did not report a standard deviation for ROI 5.

We propose that acceptable reported values for $\mathrm{SUV}_{STD}$ for ROI 5 be within 0.399 and 0.402.

# ROI 6 Results




(a) Theoretical $SUV_{max}$ versus ROI 6 diameter

(b) User Reported $SUV_{max}$ from ROI 6

Figure 25: Theoretical and Reported results for the $SUV_{max}$ for ROI 6 (See also Figure 37)

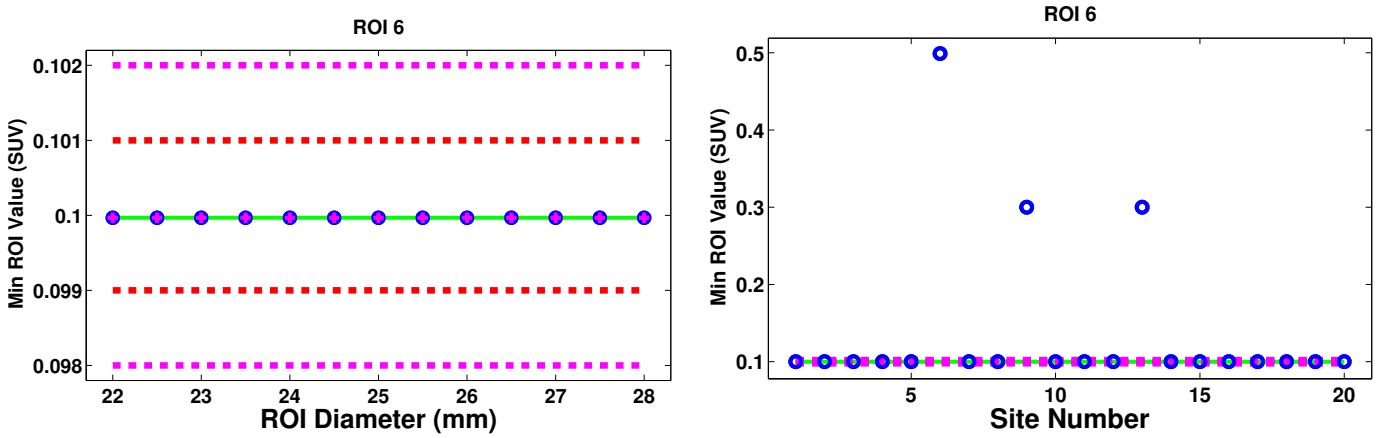
In Figure 25, we see the results for the $SUV_{max}$ for ROI 6. The theoretical $SUV_{max}$ values are independent of the center position or the diameter of the ROI.

The theoretical $SUV_{max}$ for ROI 6 should be 0.900, the SUV value of the hot voxels in the checkerboard.

User-reported $SUV_{max}$ values for ROI 6 range from 0.499 to 0.9.

Two users did not report an $SUV_{max}$ for ROI 6 (or for any spherical ROI measurement).

We propose that acceptable reported values for $SUV_{max}$ for ROI 6 be within 0.899 and 0.901.




(a) Theoretical $SUV_{min}$ versus ROI 6 diameter

(b) User Reported $SUV_{min}$ from ROI 6

Figure 26: Theoretical and Reported results for the $SUV_{min}$ for ROI 6 (See also Figure 38)

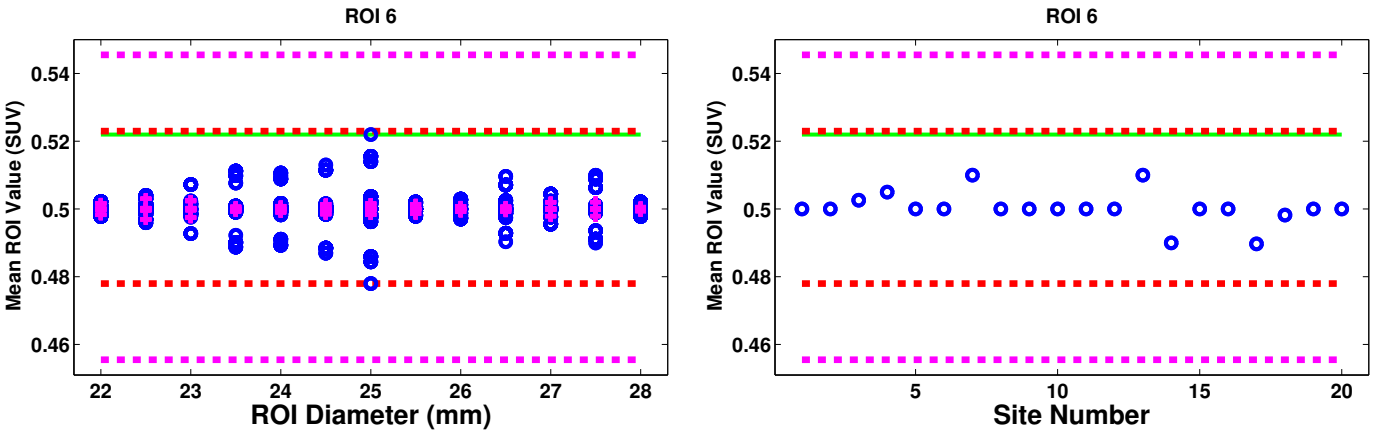
In Figure 26, we see the results for the $SUV_{min}$ for ROI 6. The theoretical $SUV_{min}$ values are independent of the center position or the diameter of the ROI.

The theoretical $SUV_{min}$ for ROI 6 should be 0.100, the value of the cold voxels in the checkerboard.

The user-reported $SUV_{min}$ values for ROI 6 range from 0.099977 to 0.499.

Two users did not report an $SUV_{min}$ for ROI 6 (or for any spherical ROI measurement).

We propose that acceptable reported values for $SUV_{min}$ for ROI 6 be within 0.099 and 0.101.




(a) Theoretical $\text{SUV}_{mean}$ versus ROI 6 diameter

(b) User Reported $\text{SUV}_{mean}$ from ROI 6

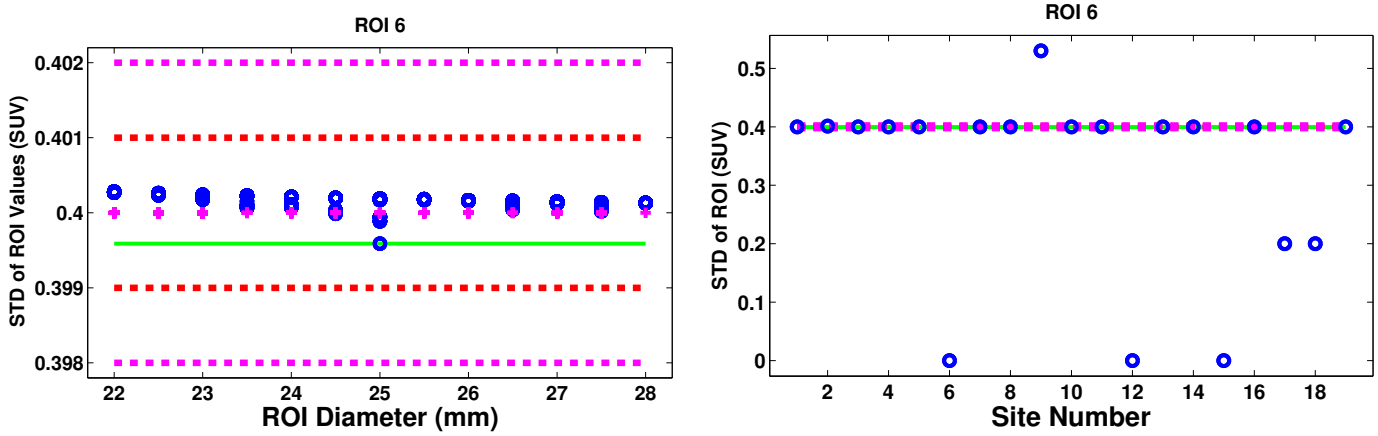
Figure 27: Theoretical and Reported results for the $\text{SUV}_{mean}$ for ROI 6

In Figure 27, we see the results for the $\text{SUV}_{mean}$ for ROI 6. Note that as the diameter and center position of a theoretical ROI changes, the ratio of cold-to-hot checkerboard voxels can change, creating a range of $\text{SUV}_{mean}$ values.

The theoretical $\text{SUV}_{mean}$ for ROI 6 should be 0.500, the mean of an equal number of 0.100 valued checkerboard voxels and 0.900 valued checkerboard voxels. For a circular ROI of 25 mm diameter and centered on the center voxel of the checkerboard, matlab reports an $\text{SUV}_{mean}$ of 0.522 using the center-inclusion method. (The checkerboard has an odd number of rows and columns.)

The user-reported $\text{SUV}_{mean}$ values for ROI 6 range from 0.489707 to 0.51.

We propose that acceptable reported values for $\text{SUV}_{mean}$ for ROI 6 be within 0.478 and 0.523 .




(a) Theoretical Standard Deviation of SUV values in ROI 6 versus ROI 6 diameter

(b) User Reported Standard Deviation of SUV values in ROI 6

Figure 28: Theoretical and Reported results for the standard deviation of ROI 6 (See also Figure 39)

In Figure 28, we see the results for the standard deviation of the voxels in ROI 6. As the diameter and center position of a theoretical ROI change, the ratio of cold-to-hot checkerboard voxels can change, resulting in a range of standard deviation values. These values must necessarily be greater than or equal to 0.400, the theoretical value.

The theoretical standard deviation for ROI 6 should be 0.400, the standard deviation of an equal number of 0.100 valued checkerboard voxels and 0.900 valued checkerboard voxels. For a circular ROI of 25 mm diameter and centered on the center voxel of the checkerboard, matlab reports a standard deviation of 0.400 using the center-inclusion method.

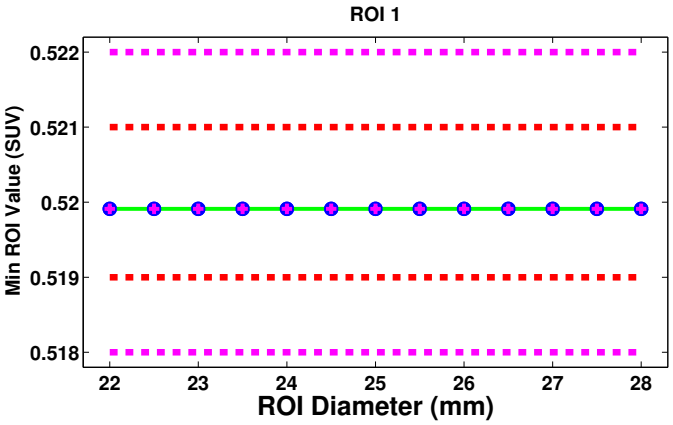
The user-reported standard deviation values for ROI 6 range from 0.00 to 0.53. Three users reported a standard deviation less than 0.40.

Five users did not report a standard deviation for ROI 6.

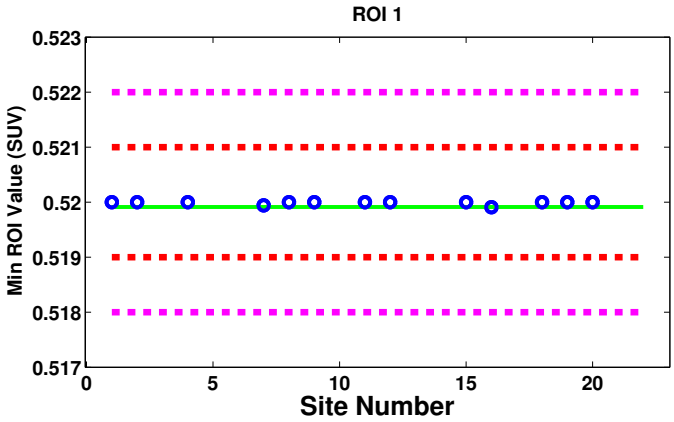
We propose that acceptable reported values for $\mathrm{SUV}_{STD}$ for ROI 6 be within 0.399 and 0.401.

# 5 Supplental Figures

Zoomed-in versions of some of the user-reported data:

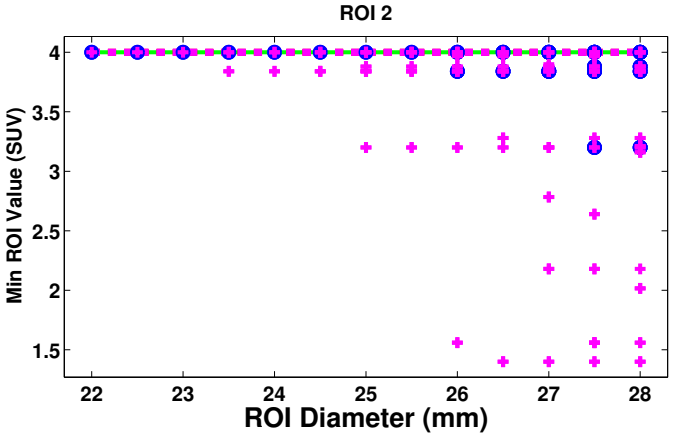



(a) Theoretical $\text{SUV}_{min}$ versus ROI 1 diameter

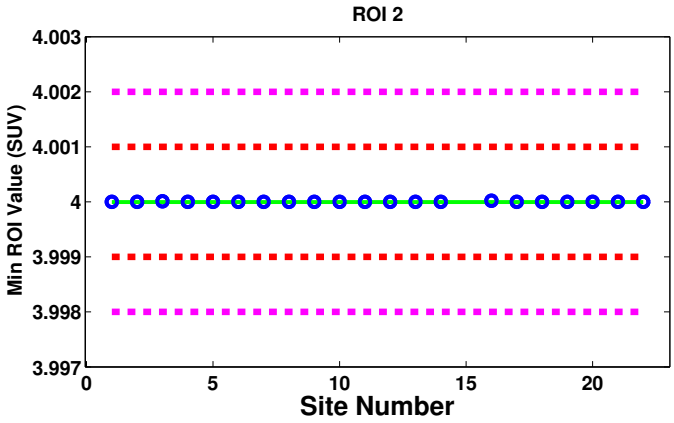



(b) User Reported $\text{SUV}_{min}$ from ROI 1

Figure 29: Theoretical and Reported results for the $\text{SUV}_{min}$ for ROI 1 (See also Figure 6)

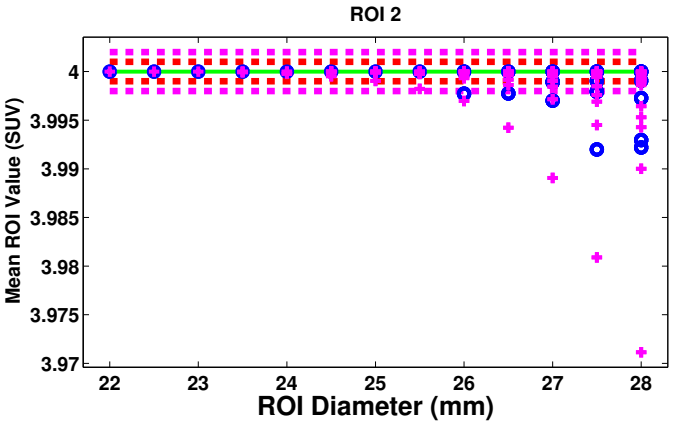



(a) Theoretical $\text{SUV}_{min}$ versus ROI 2 diameter

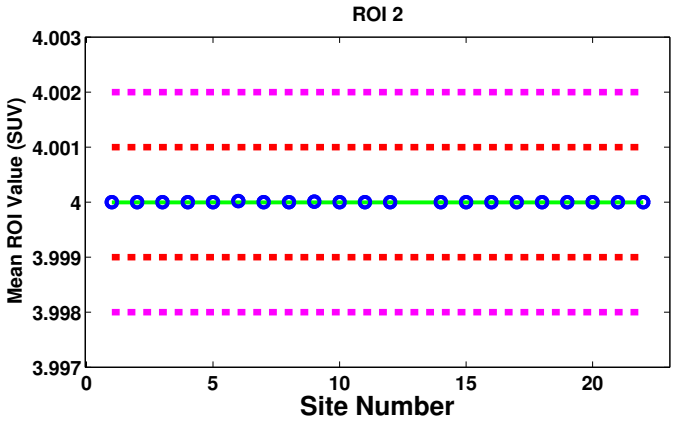



(b) User Reported $\text{SUV}_{min}$ from ROI 2

Figure 30: Theoretical and Reported results for the $\text{SUV}_{min}$ for ROI 2 (See also Figure 10)

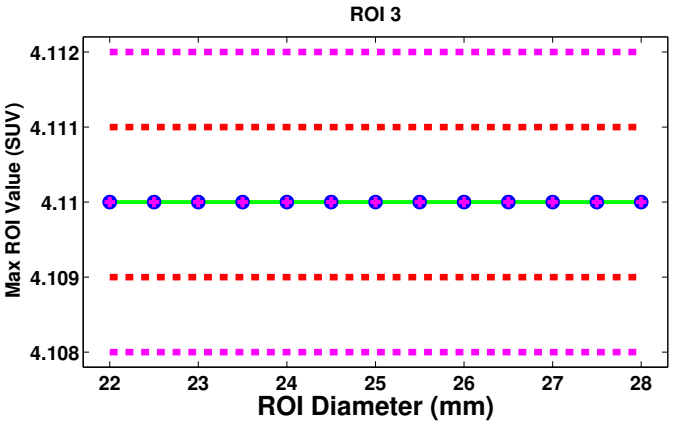



(a) Theoretical $\text{SUV}_{mean}$ versus ROI 2 diameter

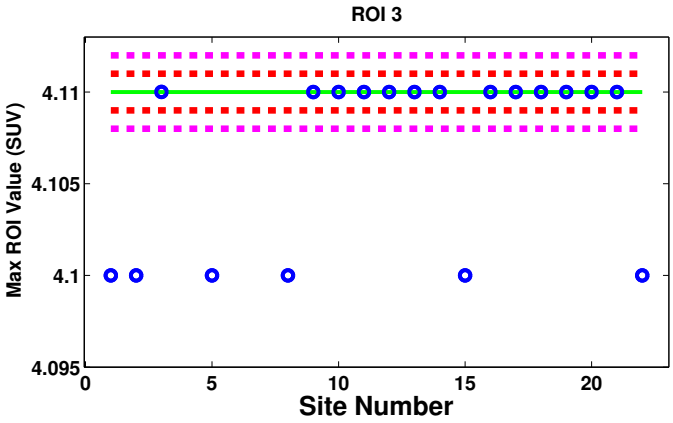



(b) User Reported $\text{SUV}_{mean}$ from ROI 2

Figure 31: Theoretical and Reported results for the $\text{SUV}_{mean}$ for ROI 2 (See also Figure 11)

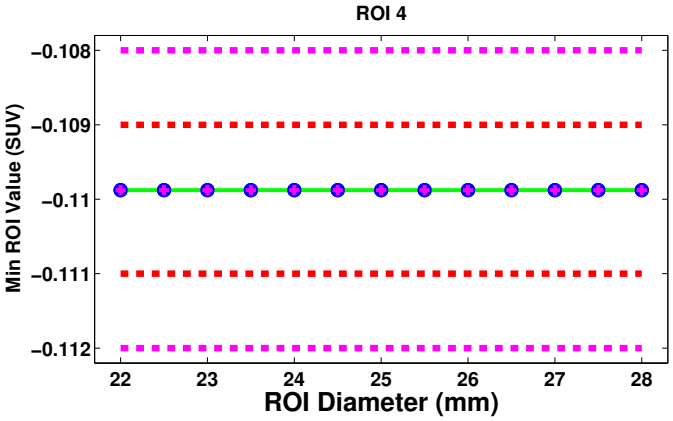



(a) Theoretical $\text{SUV}_{max}$ versus ROI 3 diameter

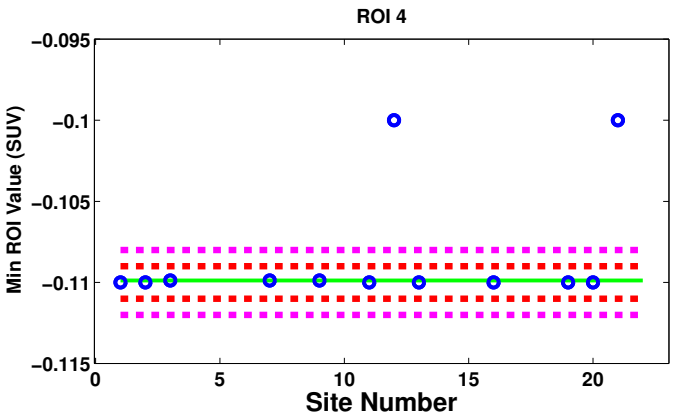



(b) User Reported $\text{SUV}_{max}$ from ROI 3

Figure 32: Theoretical and Reported results for the $\text{SUV}_{max}$ for ROI 3 (See also Figure 13)

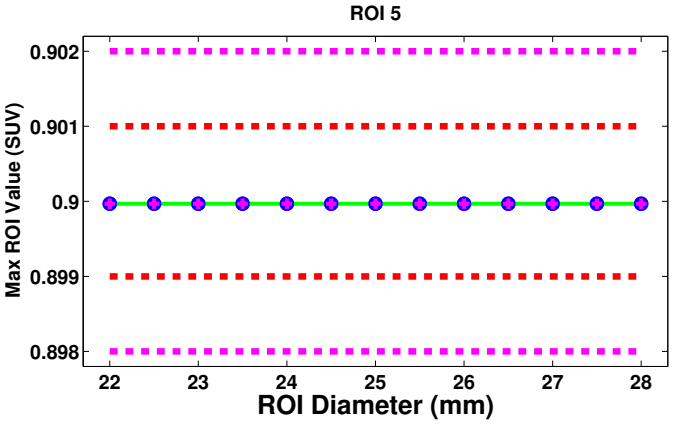



(a) Theoretical $\text{SUV}_{min}$ versus ROI 4 diameter

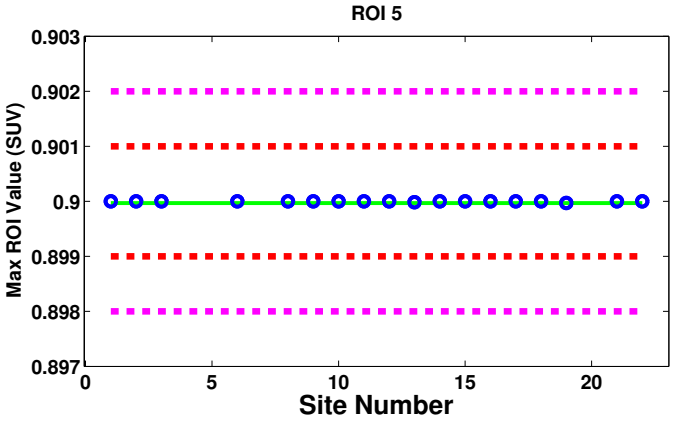



(b) User Reported $\text{SUV}_{min}$ from ROI 4

Figure 33: Theoretical and Reported results for the $\text{SUV}_{min}$ for ROI 4 (See also Figure 18)

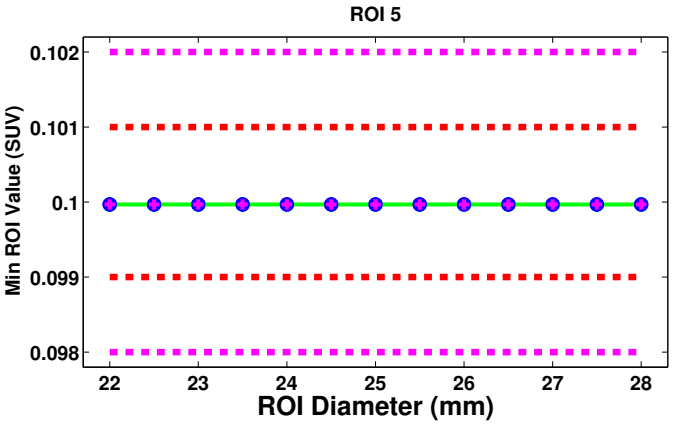



(a) Theoretical $\text{SUV}_{max}$ versus ROI 5 diameter

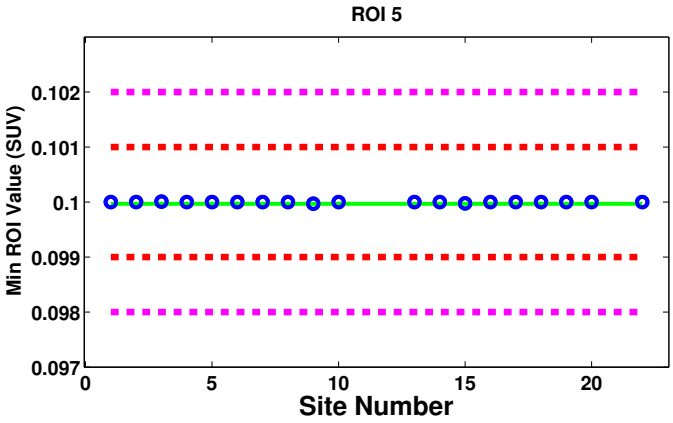



(b) User Reported $\text{SUV}_{max}$ from ROI 5

Figure 34: Theoretical and Reported results for the $\text{SUV}_{max}$ for ROI 5 (See also Figure 21)

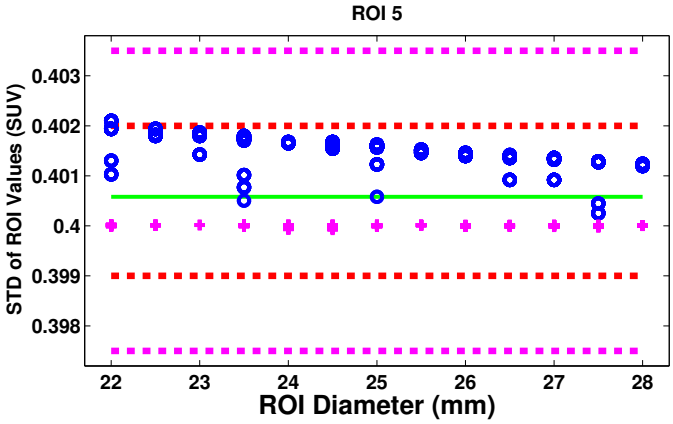



(a) Theoretical $SUV_{min}$ versus ROI 5 diameter

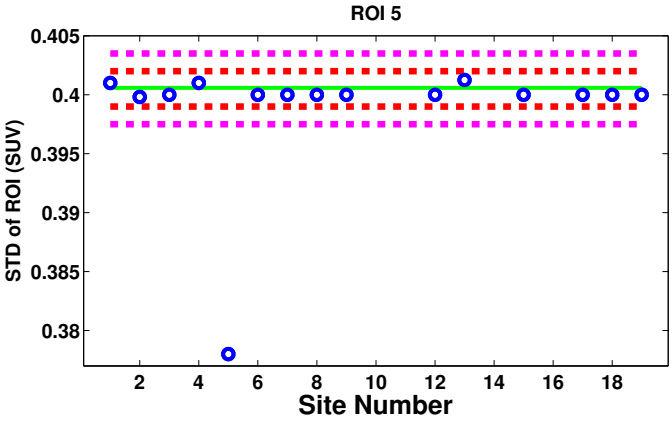



(b) User Reported $SUV_{min}$ from ROI 5

Figure 35: Theoretical and Reported results for the $SUV_{min}$ for ROI 5 (See also Figure 22)

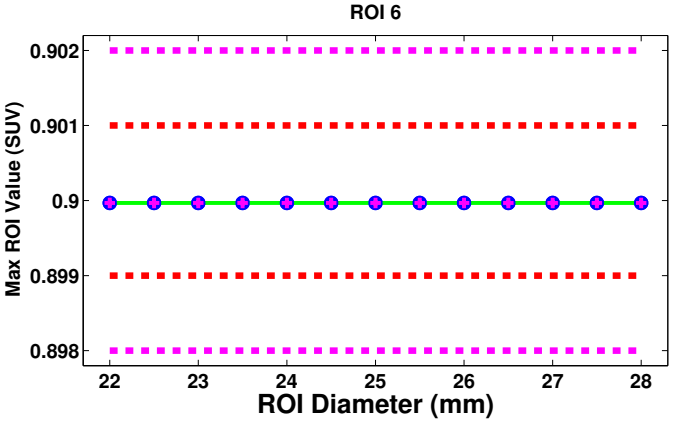



(a) Theoretical Standard Deviation of SUV values in ROI 5 versus ROI 5 diameter

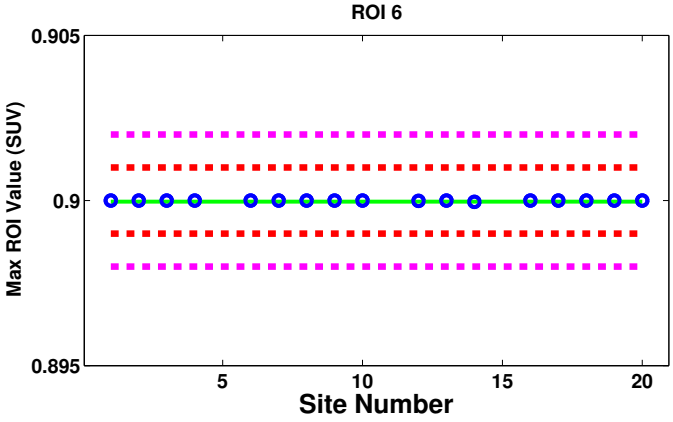



(b) User Reported Standard Deviation of SUV values in ROI 5

Figure 36: Theoretical and Reported results for the standard deviation of ROI 5 (See also Figure 24)

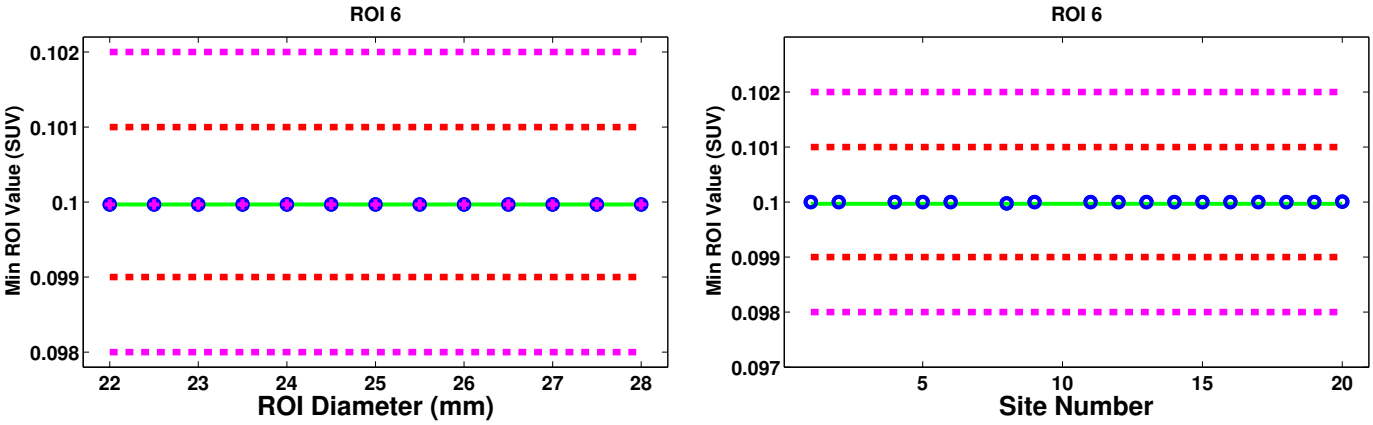



(a) Theoretical $SUV_{max}$ versus ROI 6 diameter




(b) User Reported $SUV_{max}$ from ROI 6

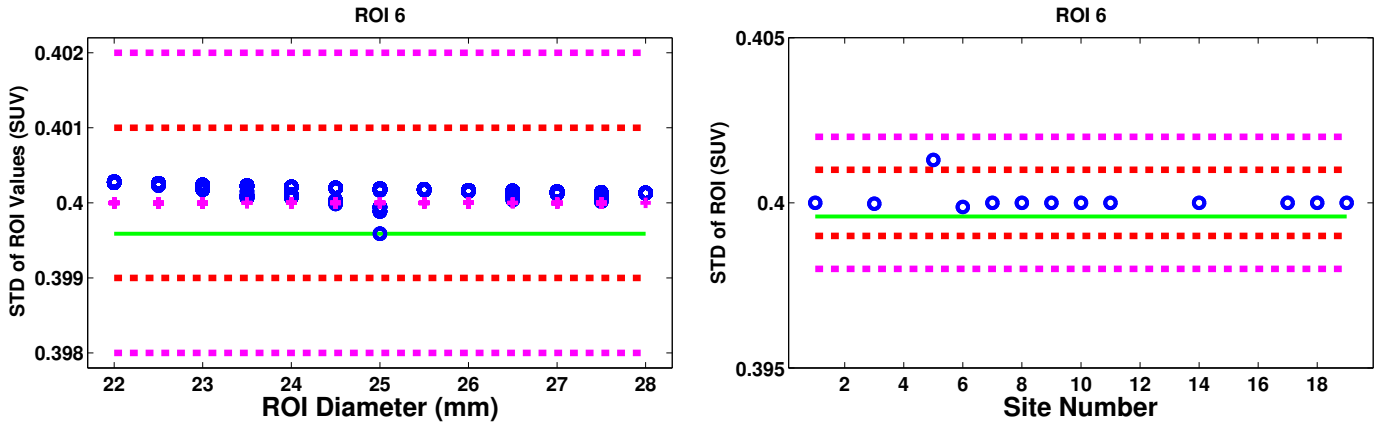
Figure 37: Theoretical and Reported results for the $SUV_{max}$ for ROI 6 (See also Figure 25)




(a) Theoretical $\text{SUV}_{min}$ versus ROI 6 diameter

(b) User Reported $\text{SUV}_{min}$ from ROI 6

Figure 38: Theoretical and Reported results for the $\text{SUV}_{min}$ for ROI 6 (See also Figure 26)




(a) Theoretical Standard Deviation of SUV values in ROI 6 versus ROI 6 diameter

(b) User Reported Standard Deviation of SUV values in ROI 6

Figure 39: Theoretical and Reported results for the standard deviation of ROI 6 (See also Figure 28)

# 6 Alternative Buffer Zone Sizes

To add to the buffer zone analysis, we performed the color-coding with buffer zones that were 25%, and 100% of the threshold range as well as the 50% buffer shown above. The results of the different bounds are shown in Table 1.

| | | MAX | | MIN | | MEAN | | STD | |
|---|---|---|---|---|---|---|---|---|---|
| | | yellow | red | yellow | red | yellow | red | yellow | red |
| ROI 1 | 25% | 0 | 0 | 0 | 9 | 4 | 3 | 1 | 2 |
| | 50% | 0 | 0 | 0 | 9 | 5 | 2 | 1 | 2 |
| | 100% | 0 | 0 | 0 | 9 | 7 | 0 | 3 | 0 |
| ROI 2 | 25% | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 2 |
| | 50% | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 2 |
| | 100% | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 2 |
| ROI 3 | 25% | 0 | 9 | 0 | 0 | 0 | 10 | 0 | 4 |
| | 50% | 0 | 9 | 0 | 0 | 0 | 10 | 0 | 4 |
| | 100% | 0 | 9 | 0 | 0 | 2 | 8 | 2 | 2 |
| ROI 4 | 25% | 0 | 0 | 0 | 12 | 0 | 10 | 1 | 5 |
| | 50% | 0 | 0 | 0 | 12 | 1 | 9 | 1 | 5 |
| | 100% | 0 | 0 | 0 | 12 | 10 | 0 | 2 | 4 |
| ROI 5 | 25% | 0 | 4 | 0 | 3 | 0 | 6 | 0 | 5 |
| | 50% | 0 | 4 | 0 | 3 | 0 | 6 | 0 | 5 |
| | 100% | 0 | 4 | 0 | 3 | 0 | 6 | 0 | 5 |
| ROI 6 | 25% | 0 | 3 | 0 | 3 | 0 | 0 | 1 | 4 |
| | 50% | 0 | 3 | 0 | 3 | 0 | 0 | 1 | 4 |
| | 100% | 0 | 3 | 0 | 3 | 0 | 0 | 1 | 4 |

Table 1: The number of red and yellow cells for each ROI measurement for each of the three buffer zone widths.

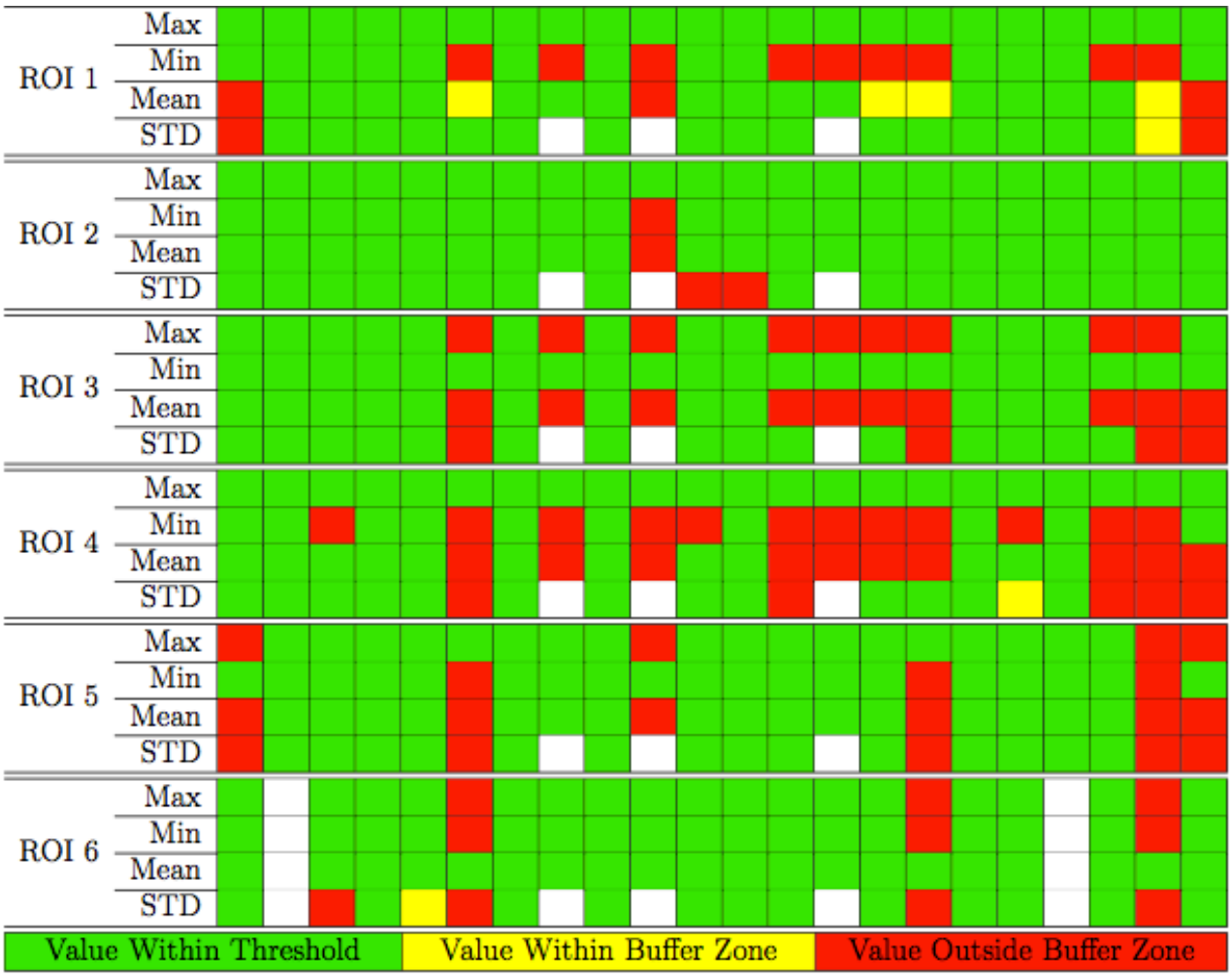



Figure 40: Color coding similar to Figure 3 and 41 using a buffer zone equal to 25% of the threshold range.

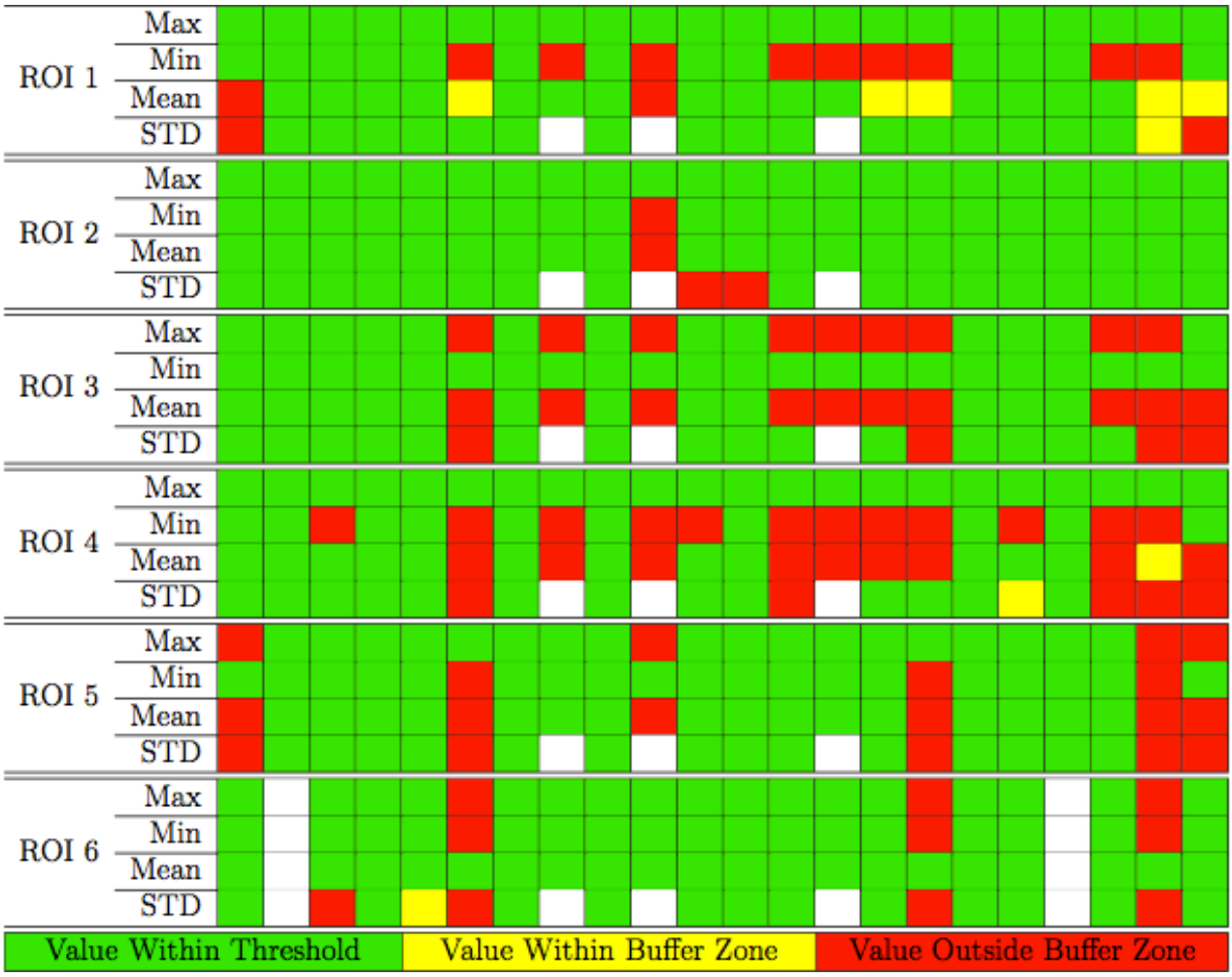



Figure 41: Repeat of Figure 3 (buffer zone is 50% of threshold) for comparison.

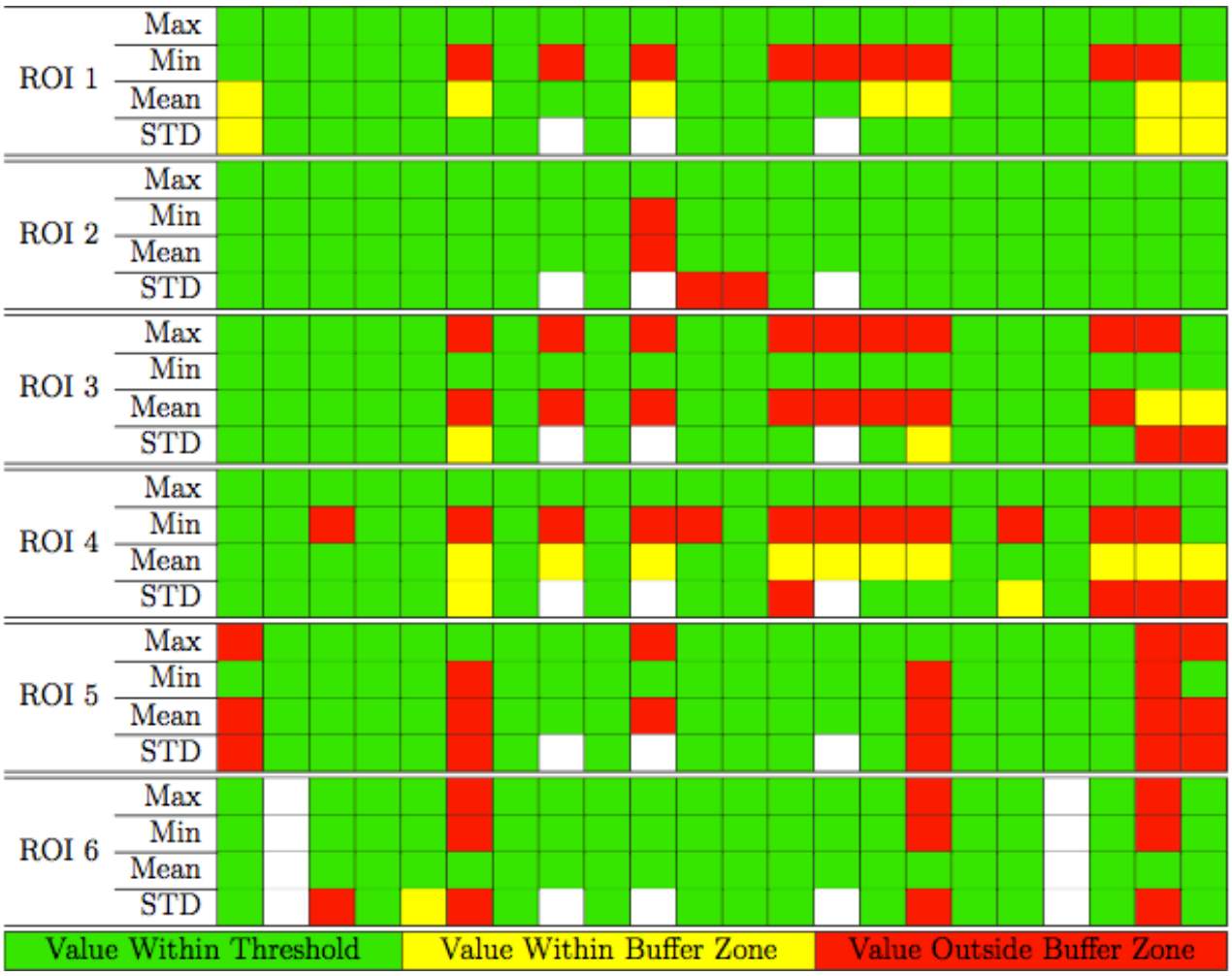



Figure 42: Color coding similar to Figure 3 and 41 using a buffer zone equal to 100% of the threshold range.