

# Nuclear Medicine/PET Phantom Image Atlas

<b>INTRODUCTION .....</b>	<b>1</b>
<b>GENERAL TIPS AND REMINDERS.....</b>	<b>2</b>
<b>PLANAR.....</b>	<b>3</b>
<b>Uniformity .....</b>	<b>3</b>
<b>Spatial Resolution.....</b>	<b>6</b>
<b>Non-traditional scanners .....</b>	<b>7</b>
<b>SPECT .....</b>	<b>8</b>
<b>Traditional scanners .....</b>	<b>8</b>
<b>Non-traditional scanners .....</b>	<b>12</b>
<b>Cardiac Scanner with 180° acquisition.....</b>	<b>14</b>
<b>Small SPECT Phantom .....</b>	<b>15</b>
<b>PET .....</b>	<b>16</b>
<b>ARTIFACTS .....</b>	<b>20</b>
<b>Planar .....</b>	<b>20</b>
<b>SPECT .....</b>	<b>24</b>
<b>PET .....</b>	<b>29</b>

## INTRODUCTION

*This atlas is meant as a guide to help sites with physics qualification materials for the NM and/or PET ACR accreditation. The atlas provides tips and reminders as well as sample images required for submission. It also includes examples of images with artifacts that should **not** be included in the submission.*

The links below will direct users to requirements for NM & PET Clinical and Phantom submissions. Please review carefully prior to the uploading of images and submission of the testing packets.

<https://accreditationsupport.acr.org/support/solutions/articles/11000062796-accreditation-testing-overview-nuclear-medicine-and-pet>

<https://accreditationsupport.acr.org/support/solutions/articles/11000062797-clinical-image-testing-nuclear-medicine>

<https://accreditationsupport.acr.org/support/solutions/articles/11000062798-phantom-images-nuclear-medicine>

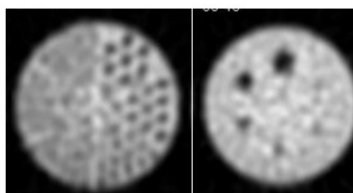
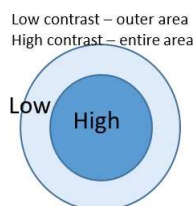
<https://accreditationsupport.acr.org/support/solutions/articles/11000062799-clinical-image-testing-pet>

<https://accreditationsupport.acr.org/support/solutions/articles/11000062800-phantom-testing-pet>

The link below will display phantom criteria:

<https://accreditationsupport.acr.org/support/solutions/articles/11000080933-phantom-criteria-revised-1-6-20->

When evaluating low and high contrast, please refer to the images below.



The first (12.7mm) and second (11.1mm) rod sectors are seen with high contrast while the other rods are of low contrast. The first (31.8mm) and second (25.4mm) spheres are seen with high contrast while the other spheres are of low contrast.

Testing packets are generated based on the exams selected in the accreditation application. If you need to make corrections to the testing packet, i.e., remove module or change exams; please submit a support ticket at the link below BEFORE submitting the testing packet.

<https://accreditationsupport.acr.org>

How can we help you today?

Enter your search term here...

SEARCH

+ New support ticket

Check ticket status

Emergency use:

If you are doing a type of scan less than 5 times a month **OR** 25 times a year, **YOU ARE NOT REQUIRED TO APPLY.**

This also applies to Tl-201, Ga-67, & In-111.

Timeframe	Acceptable Number of 'Emergency Use' Examinations/Isotopes Performed Outside a Unit's Accreditation Status		
	MRI exams	Nuclear Medicine/PET/Ultrasound exams	Nuclear Medicine Isotopes (In-111, Ga-67, and Tl-201)
30 days	Fewer than 10	Fewer than 5	Fewer than 5
12 months	Fewer than 50	Fewer than 25	Fewer than 25

## **GENERAL TIPS AND REMINDERS**

1. Incomplete or incorrect uploads (images and/or documentation) will be removed and sites will need to re-upload. This can slow down the review process.
2. Cell phone images, scanned paper or color photos and non-digital images (i.e., scanned documents saved as jpgs) are not acceptable as electronic clinical or phantom uploads. The image below on the left shows a paper print scanned and uploaded as a jpg. The image on the right is the same image submitted as a “true” digital image.



3. Look for red-lettering instructions when uploading images in the ACRedit database.



4. If your scanner is not capable of planar imaging, the application should reflect that by selecting “This unit is unable to acquire planar images.”

### **Please select isotopes for Planar Phantom**

Please tell us which of the following isotopes are used on this unit.  
From the list provided below, you **MUST** select all isotopes that apply

You must acquire your planar spatial resolution images with an ACR-approved phantom for Tc-99m if SPECT or nuclear cardiology was selected. The 4-quadrant bar phantom should be used for isotopes that are selected as planar only.

- ☒ Tc-99m
- ☐ Tl-201
- ☐ Ga-67 and/or In-111
- ☐ This unit is unable to acquire planar images



If you are submitting for Cardiac only and the scanner is capable of planar imaging, do not select this option - you will be required to submit planar uniformity and planar spatial resolution if the scanner is capable of acquiring planar images.

If you filled out the application incorrectly for your type of scanner, please submit a support ticket to request correction BEFORE submitting the testing packet.

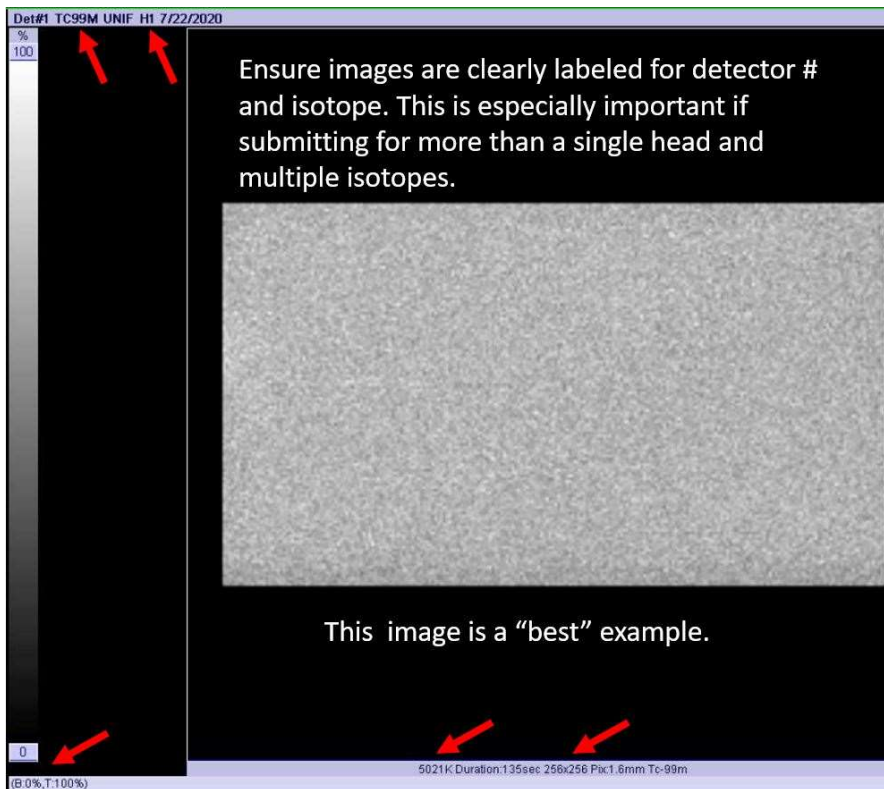
The following SPECT cameras are not required to submit planar images: D-SPECT, Digirad dedicated cardiac SPECT cameras (e.g., Cardius, 2XPO, 3XPO, X-ACT, TC2020 SPECT), Veriton, Starguide, GE 530c, GE 570c, MyoSPECT, Clearvision, and GVI.

5. The following images are examples only. They are not meant to show required formatting.

## PLANAR

### Uniformity

Phantom images **MUST** be submitted in gray scale. Please ensure isotope and detector head is identified (if submitting more than a single head). Images should include a gray scale (see image on right below).



Planar images can be formatted using 1 on 1, 2 on 1, or 4 on 1 formats. Just make sure all required images are included!

Uniformity  
single detector

Spatial  
resolution  
single detector

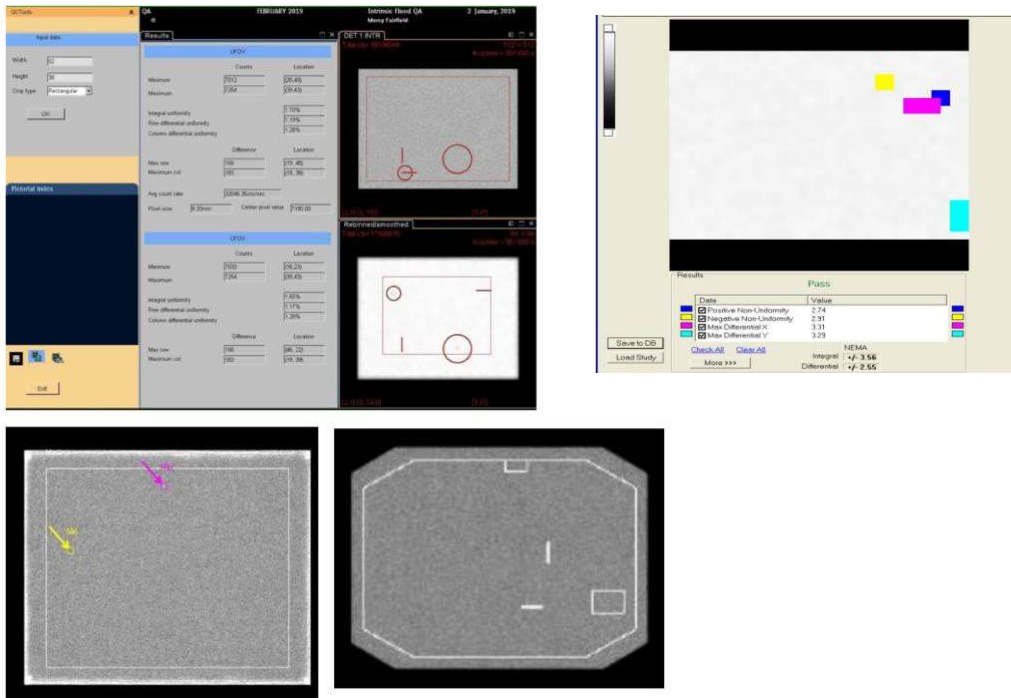
Uniformity dual  
detector  
Head 1

Spatial resolution  
dual detector  
Head 1

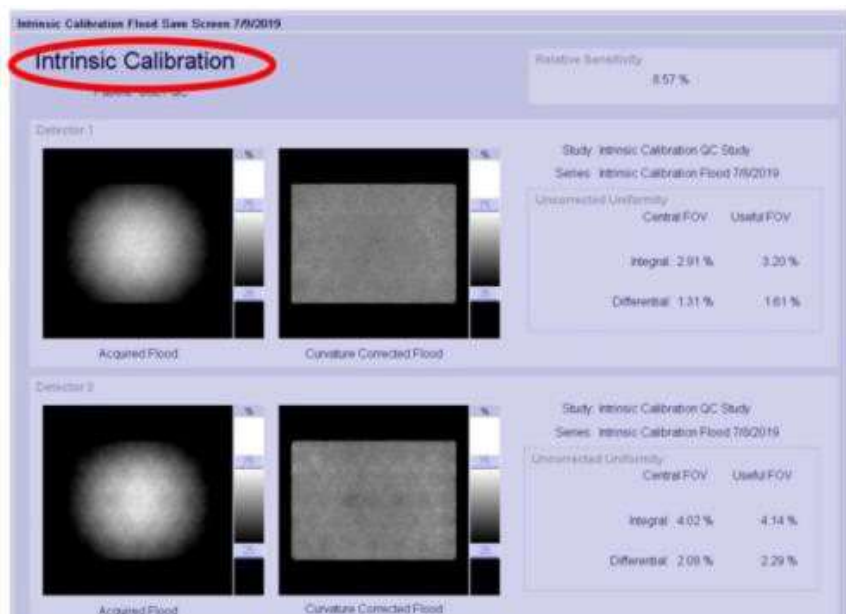
Uniformity dual  
detector  
Head 2

Spatial resolution  
dual detector  
Head 2

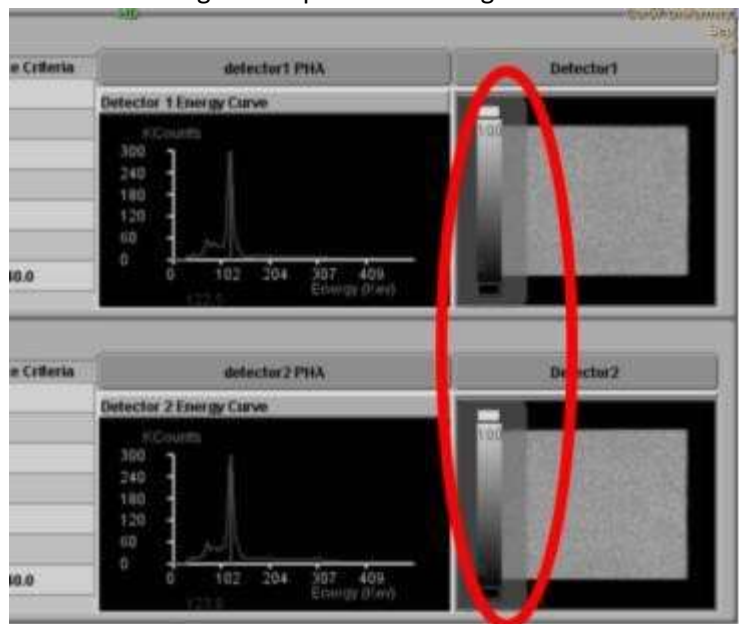
DO NOT send images with overlays.



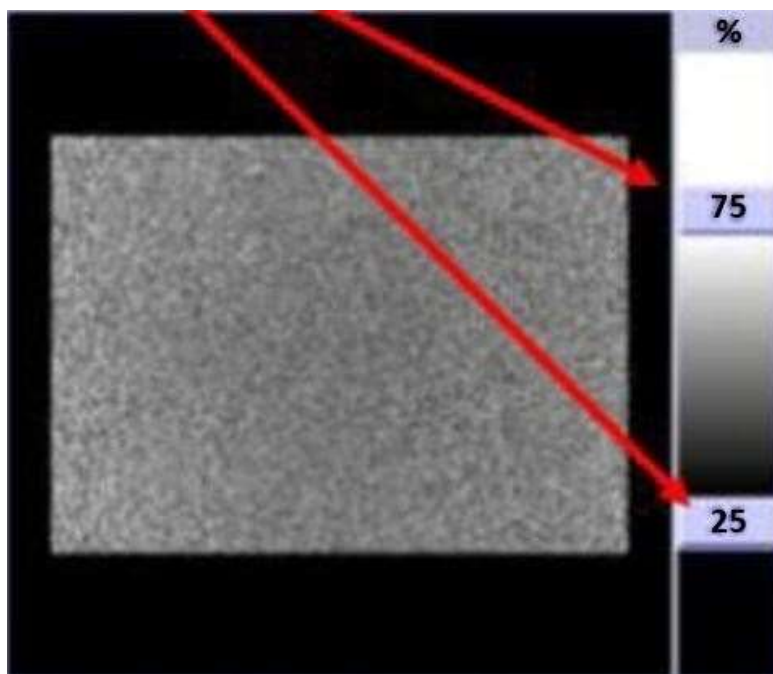
DO NOT send calibration images. Images must be acquired as outlined in the instructions. Uniformity images must be acquired with 256x256 matrix and with 5 or 10 million counts, depending on the scanner detector size, unless your scanner does not have 256x256 matrix capability (some cardiac scanners are only able to acquire 64x64 matrix). If a 256 matrix is not available, use the largest matrix available on the scanner.



DO NOT send images with part of the image obscured.

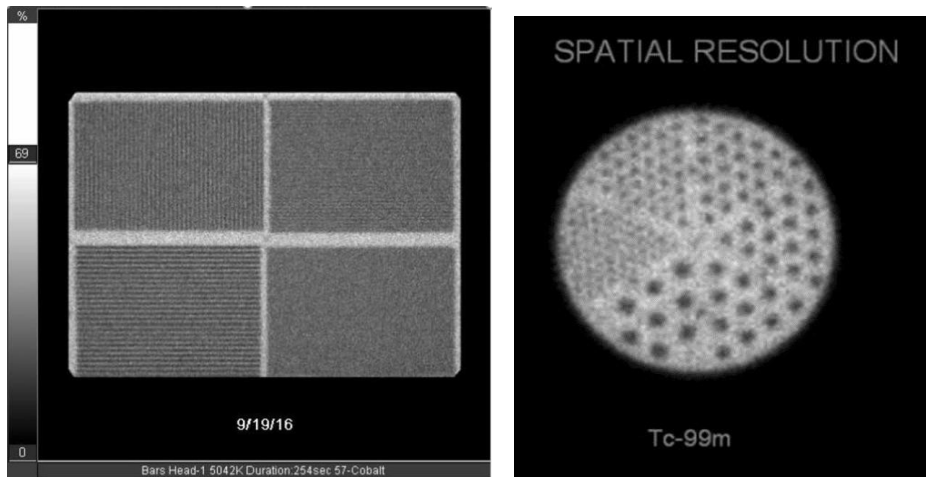


The image gray scale should be set at 0 and 100 %

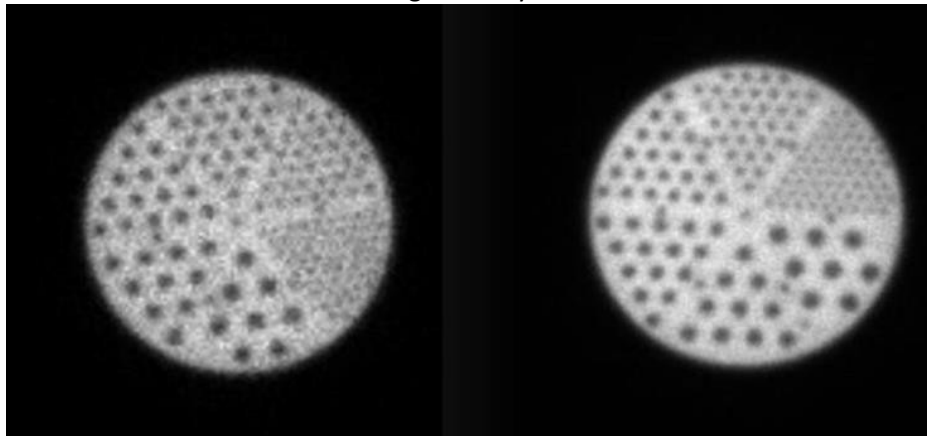


## SPATIAL RESOLUTION

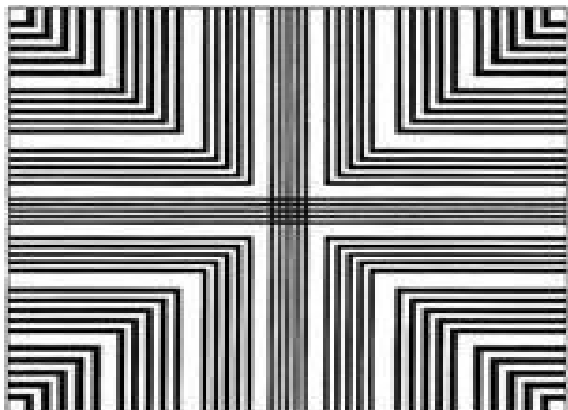
Phantom images MUST be submitted in gray scale. You may use 4 quadrant bar images OR the ACR phantom when submitting for Planar ONLY. If submitting bars, the smallest MUST be between 2-3 mm. If also submitting for SPECT/Cardiac modules, you must use the ACR phantom for the planar spatial resolution for Tc-99m. **Ensure the data form matches the images submitted.** Do not fill out the data form for ACR phantom and then upload 4 quadrant bars or fill out bar sizes in the data form and then submit ACR phantom planar spatial resolution images,



Ensure settings are correct. The image on the left is the correct 600k image. The image on the right appears to be 6 million counts based on the image density.



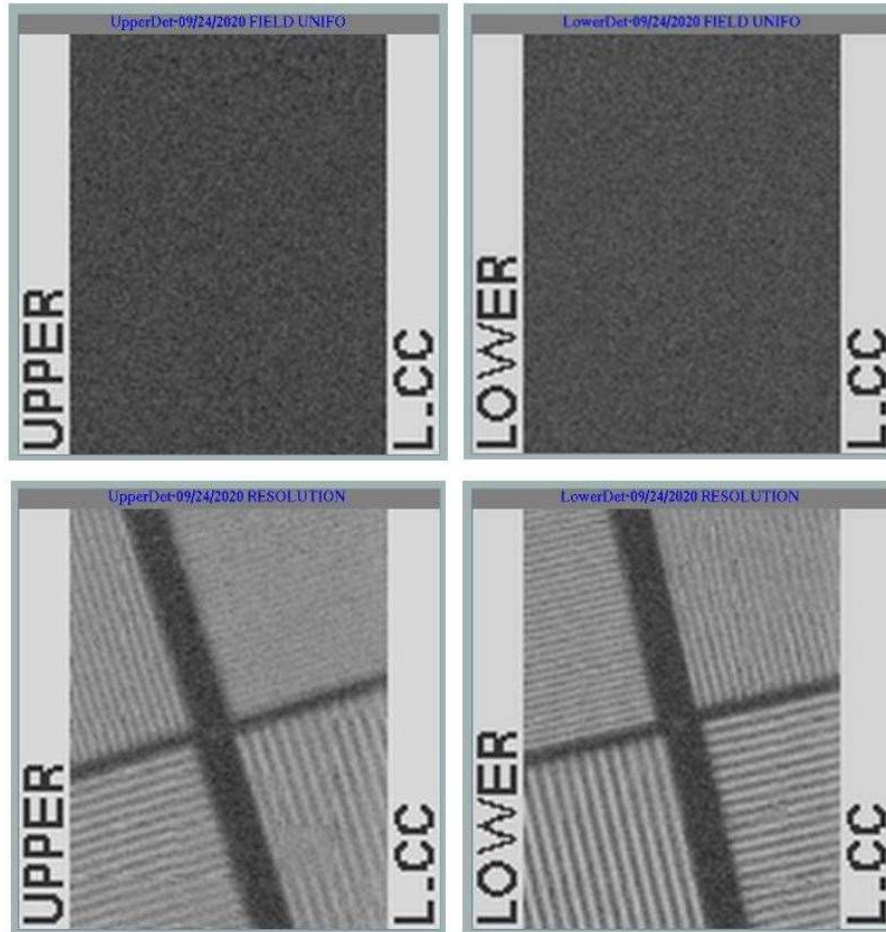
UB bars ARE NOT approved for ACR accreditation.





## Non-traditional scanners

Breast imaging scanners have a small FOV similar to mammography scanners. Because the FOV is small, follow the same instructions for small FOV cameras. For the spatial resolution, the phantom should be placed on a 45-degree angle to visualize all quadrants. The submissions will appear as shown below.



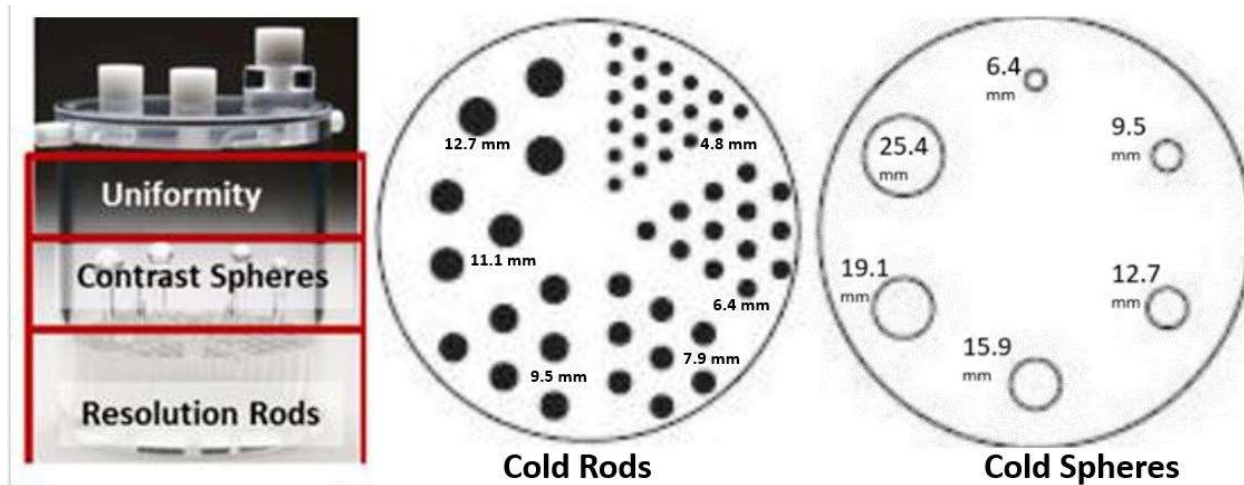


## SPECT

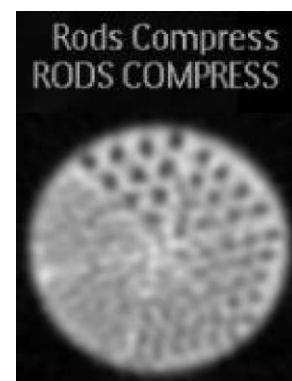
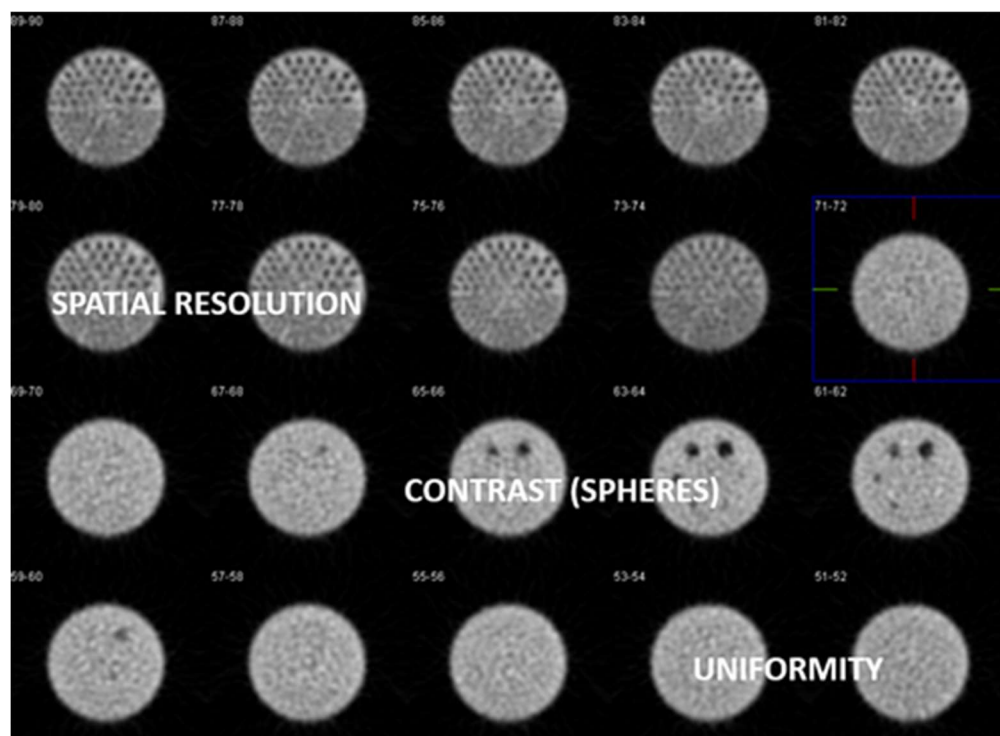
### Traditional scanners

Phantom images **MUST** be submitted in gray scale. Screen captures, jpgs, tif, etc., are acceptable for uniformity and spatial resolution. However, it is recommended to upload the slices as DICOM axial images. DICOM images allow reviewers to window and zoom.

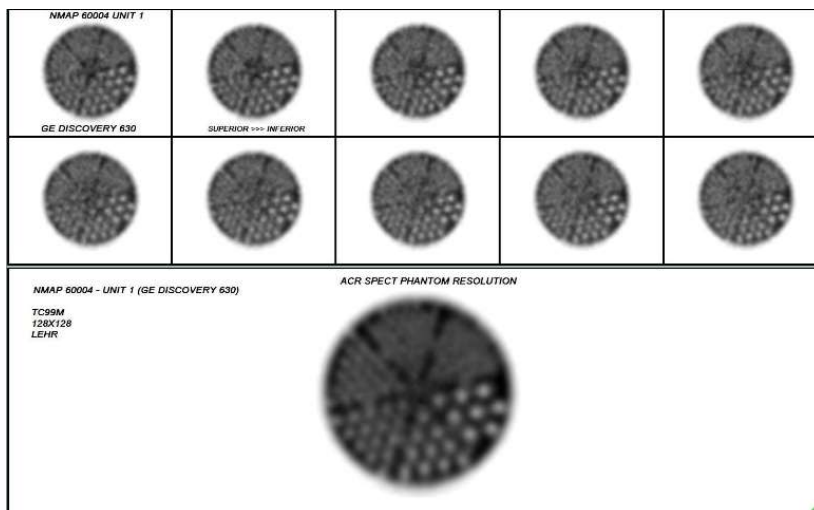
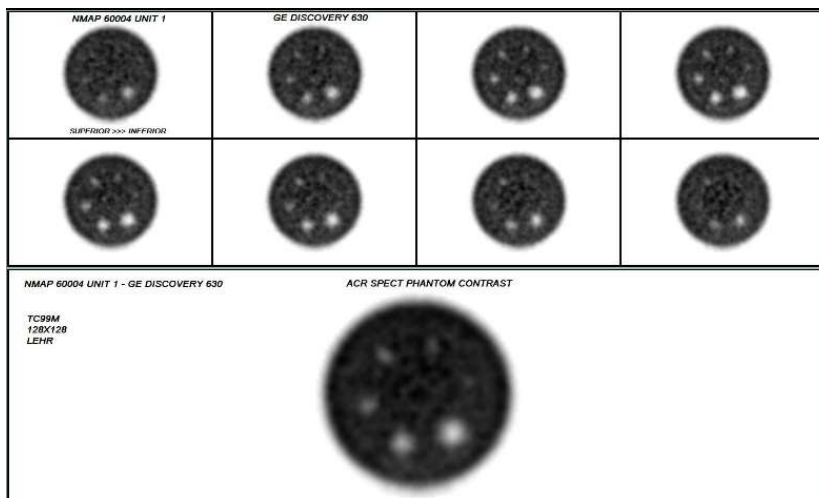
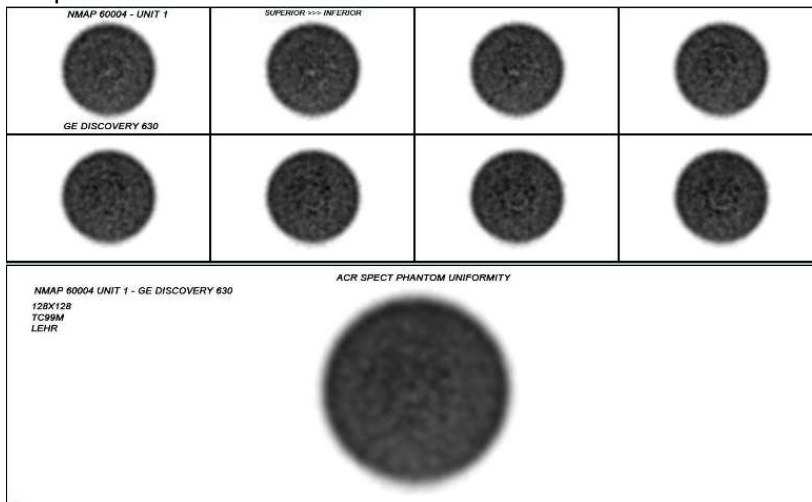
The uniformity section of the phantom is at the top, above the spheres and **NOT** the section between rods and spheres. **Include the ENTIRE SPECT volume!** All sections of the phantom are evaluated for uniformity.



Example of phantom images top to bottom. Make sure to include the summed rods with the axial SPECT slices. Failure to include the summed rods (resolution section) could reduce the resolution score.



The complete phantom top to bottom must be submitted in a single file. Using the following display is NOT acceptable.



The standard phantom is no longer approved for use. The smallest rods in the standard phantom are 6.4 mm (7 rods) while the deluxe phantom is 4.8 (10 rods). Please ensure you are using the correct phantom.

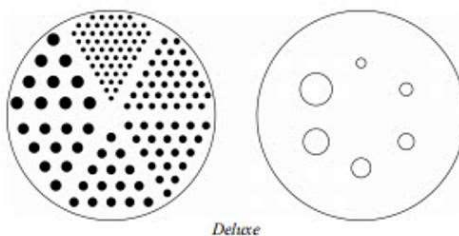
### Deluxe Jaszczak Phantom™

#### Model ECT/DLX/P

- For use with high to very high spatial resolution SPECT and PET systems.

#### Specifications:

Rod diameters: 4.8, 6.4, 7.9, 9.5, 11.1 and 12.7 mm  
Solid sphere diameters: 9.5, 12.7, 15.9, 19.1, 25.4, and 31.8 mm



*Deluxe*

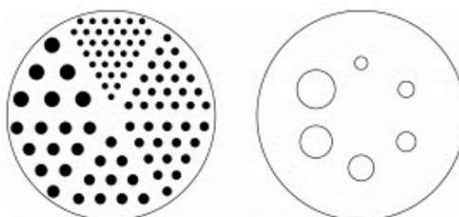
### Standard Jaszczak Phantom™

#### Model ECT/STD/P

- For use with medium to high spatial resolution SPECT and PET systems.

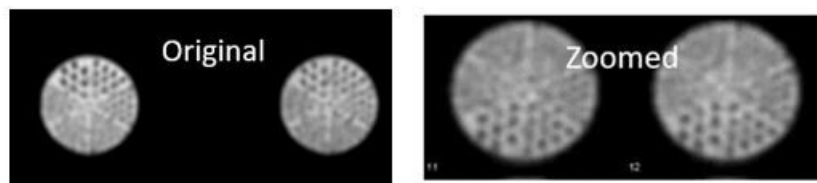
#### Specifications:

Rod diameters: 6.4, 7.9, 9.5, 11.1, 12.7 and 19.1 mm  
Solid sphere diameters: 12.7, 15.9, 19.1, 25.4, 31.8, and 38 mm

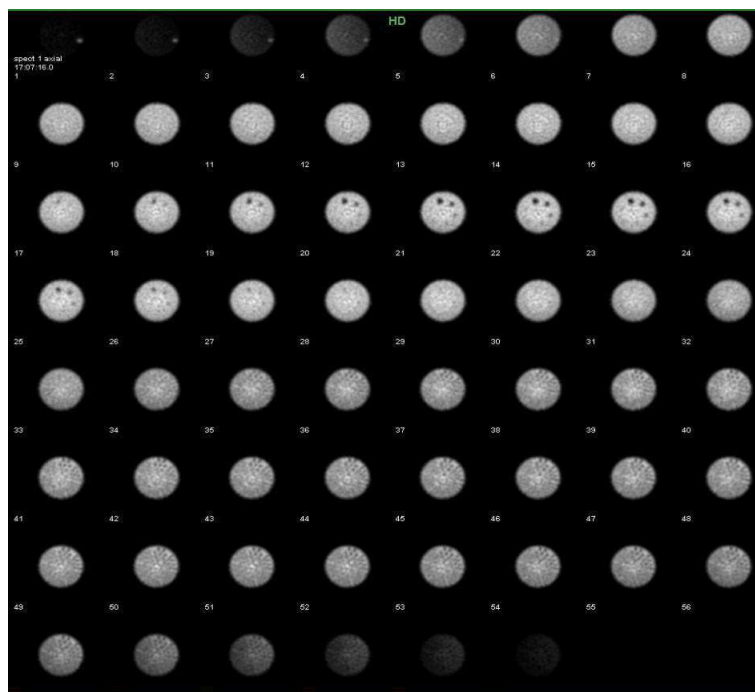


*Standard*

If submitting jpgs or screen captures, it's recommended to zoom the series so the images fill each frame.

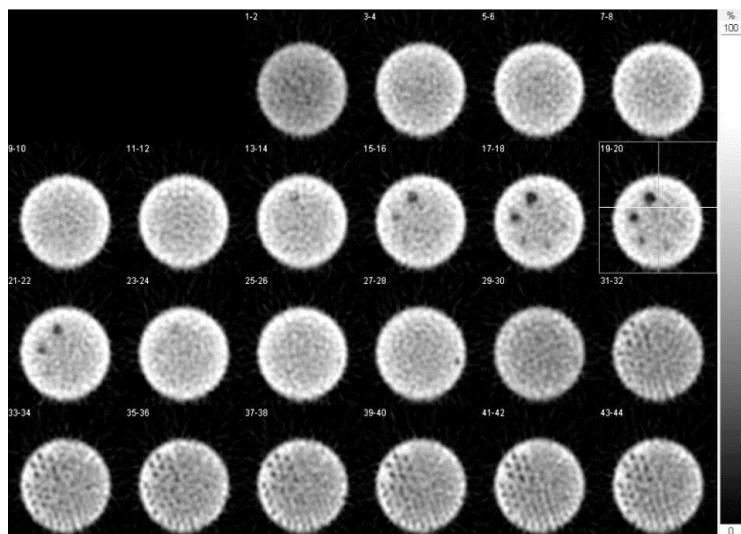


This submission in the image below should have been broken up into 2-3 pages of 9, 12 or 16 on 1 formats. These images are too small to properly evaluate. Additionally, the image below show slices that are too thin. Instructions require 6-9 mm thick slices. Images usually need to be reframed by a factor of 2 to 3 – check with your physicist if you're not sure of the slice thickness.



Attenuation correction is required if available on the scanner. A bright/dark rim on the axial image set below suggests the attenuation correction was not applied or applied incorrectly. Additionally, it's recommended to check the position of the attenuation correction region (circle) around phantom. If you are unsure of the attenuation correction factor, contact your physicist or vendor applications. Some systems do not have attenuation correction, or the saved system default attenuation correction may not be correct. The attenuation correction is a separate step and for some scanners, it may be a separate program.

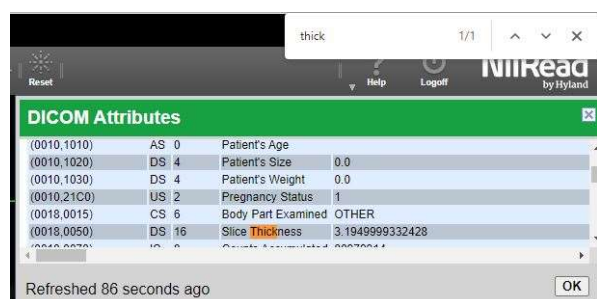
Please check with your physicist or vendor applications for instructions on processing.



The toolbar can assist with ensuring correct images are included. If DICOM slice are uploaded, intensity may be adjusted using the **Presets** tool. The **DICOM Popup** may be helpful to check for slice thickness, counts, matrix. The **Invert** tool may be used by sites and reviewers to better view the images. (These tools DO NOT work with non-DICOM).

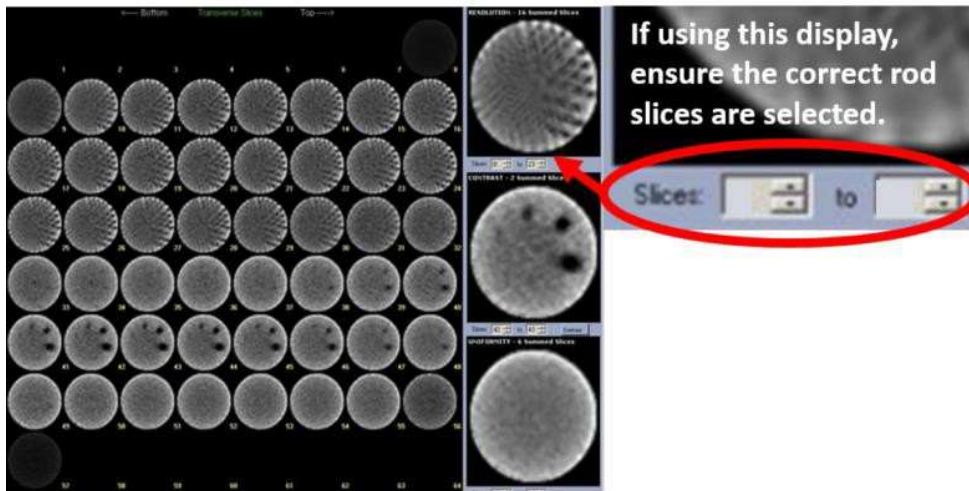


CTRL F will open a word search box. To search for matrix, search for "row". Other searches would be counts or thickness (for slice thickness it displays in mm).

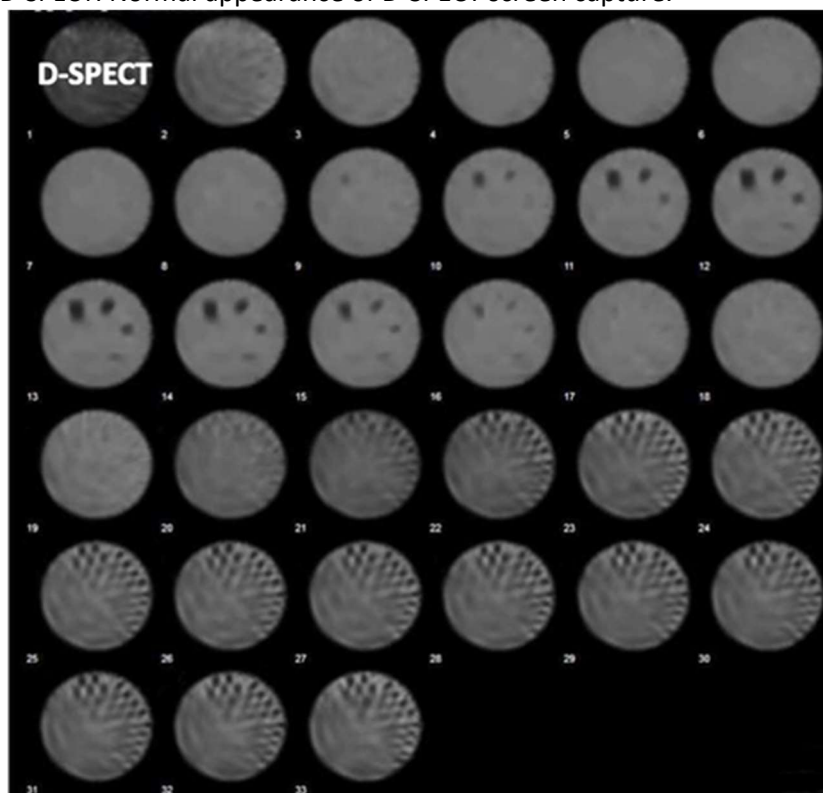


## Non-traditional scanners

Digirad: The slices displayed below are too thin, but the image shows a general SPECT display that includes the summed rods image.



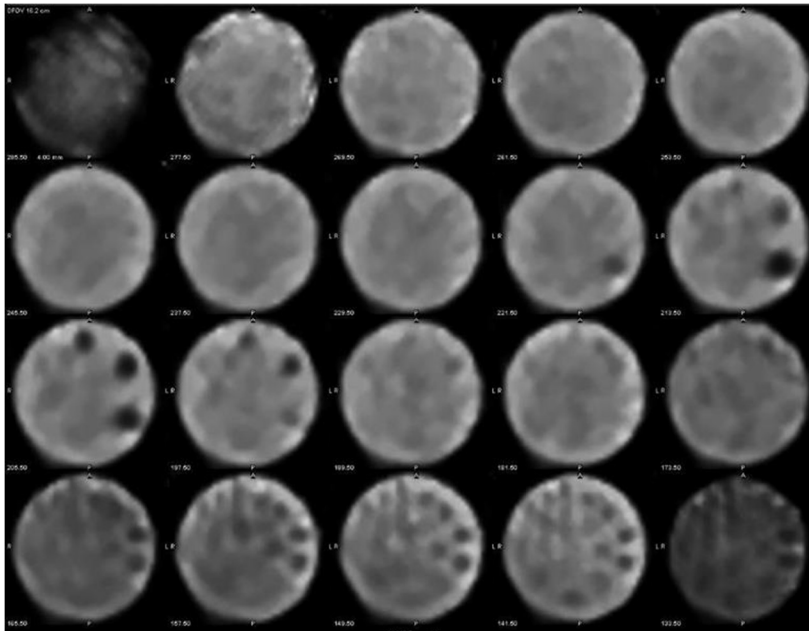
D-SPECT: Normal appearance of D-SPECT screen capture.





GE 530C:

This is a normal appearance for this type of scanner using a small phantom. A summed image is still required. CZT and non-planar scanners may look different than more commonly used general imaging scanners.



## Cardiac Scanner with 180° acquisition

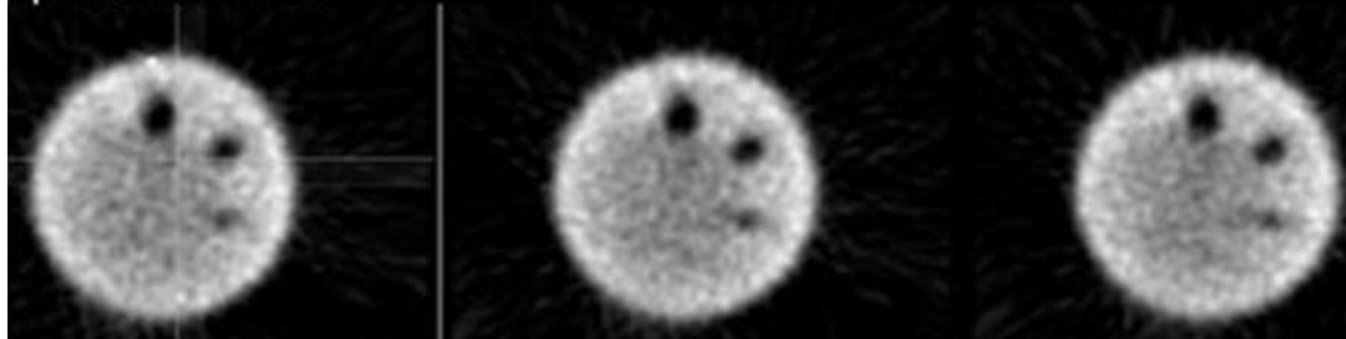
For a single detector camera which is only capable of rotating 180 degrees, rather than a complete 360 degrees, special caution must be exercised in the orientation of the spheres. The phantom must be positioned so that the largest sphere is at the center of the 180-degree sweep for frame 1. If a Dual head, fixed 90 degrees detector configuration that only has a 180-degree acquisition arc is being tested, the largest sphere must be positioned in the center of the leading detector for frame 1.

Failure to follow these directions may produce poor contrast in the spheres.

**Poor spheres positioning for a 180 degree acquisition. Only the 31.8 and 25.4 mm spheres are seen.**



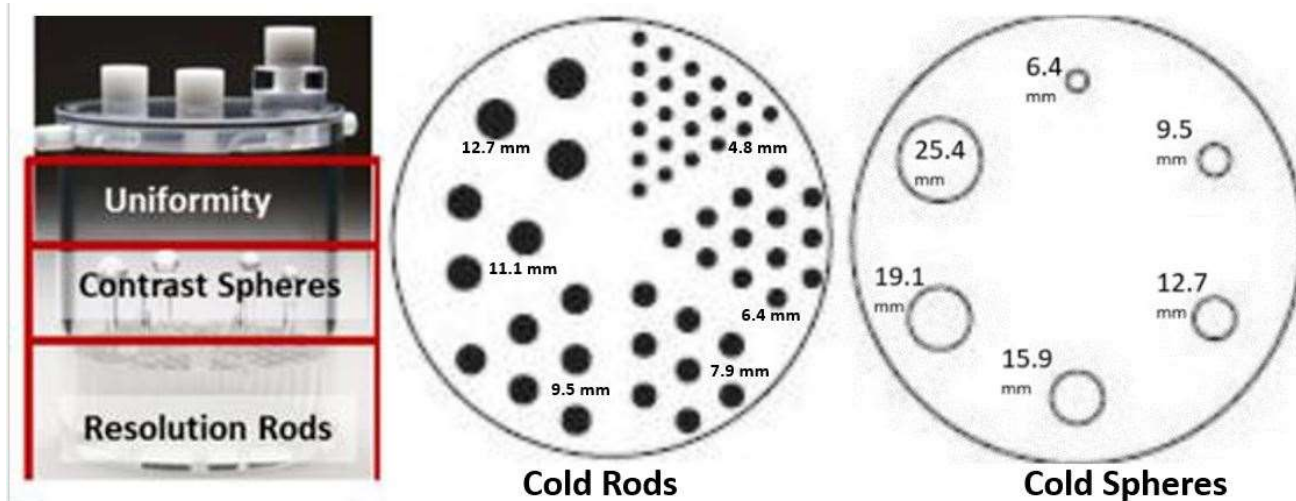
**Better positioning for a 180 degree acquisition. The 3<sup>rd</sup> 19.1 mm sphere is seen.**



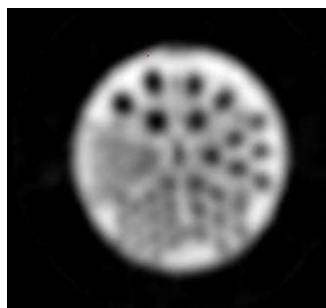


## Small SPECT Phantom

Example of a small phantom (see instructions for units approved to use the small phantom). **Ensure the data form matches the images submitted.**

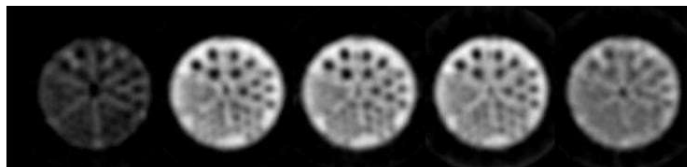


## Summed Image

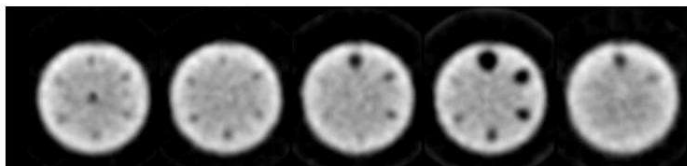


Although the images below show the individual sections of the phantom, remember that all reconstructed images must be submitted and not a representative group as shown here.

Spatial Resolution section (Rods)



Contrast section (Spheres)



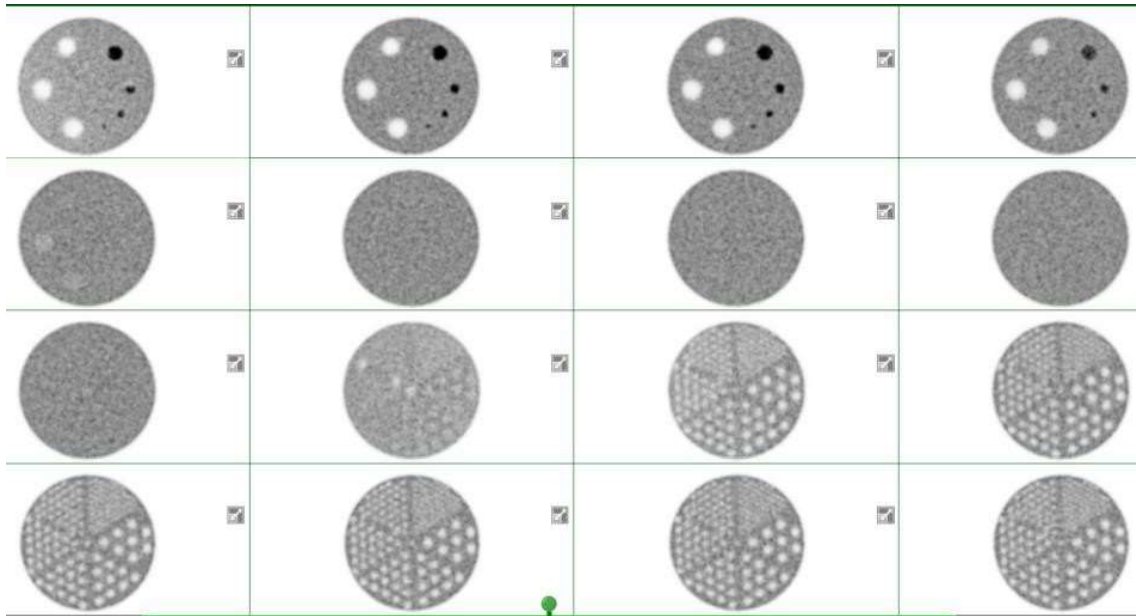
Uniformity section



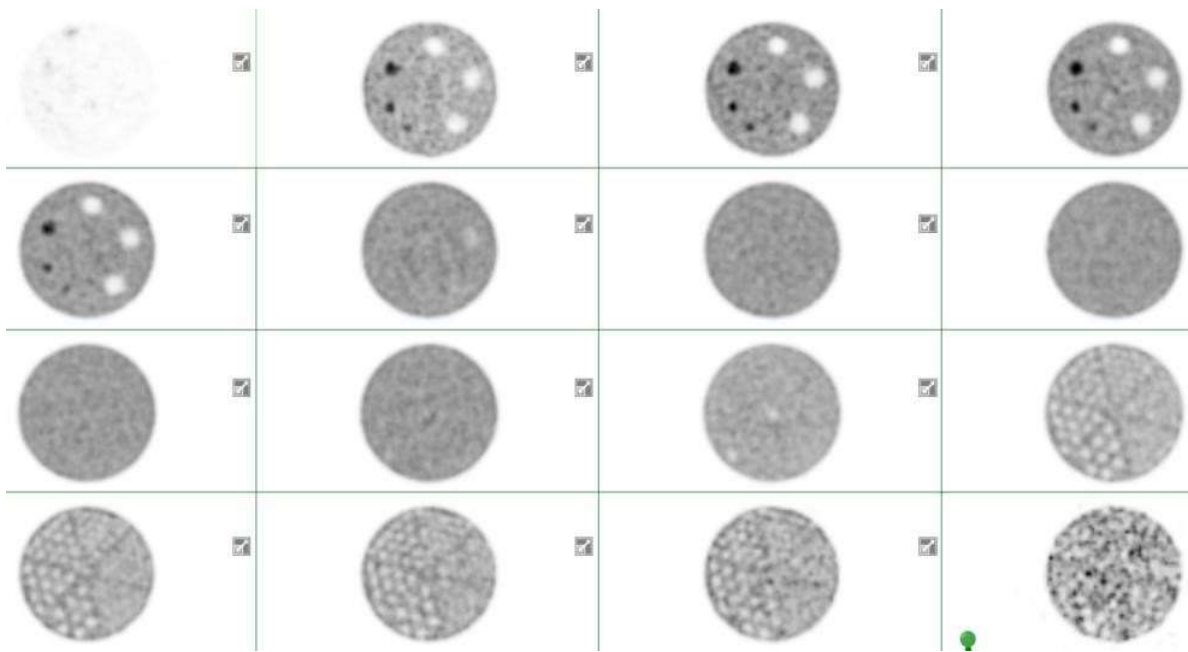
## PET

Sites are now required to upload the DICOM file for the phantom. It **MUST** include the entire phantom volume and show 1 cm thick slices. The ROI image will usually be a screen capture or jpg. DICOM images allow the reviewers to adjust the windowing, zoom, and scroll through the slices. This eliminates errors of not including all the slices, or the images being too small or inappropriately windowed. DICOM uploads will also allow the reviewers to draw ROIs to check for errors that may occur when filling out the data form.

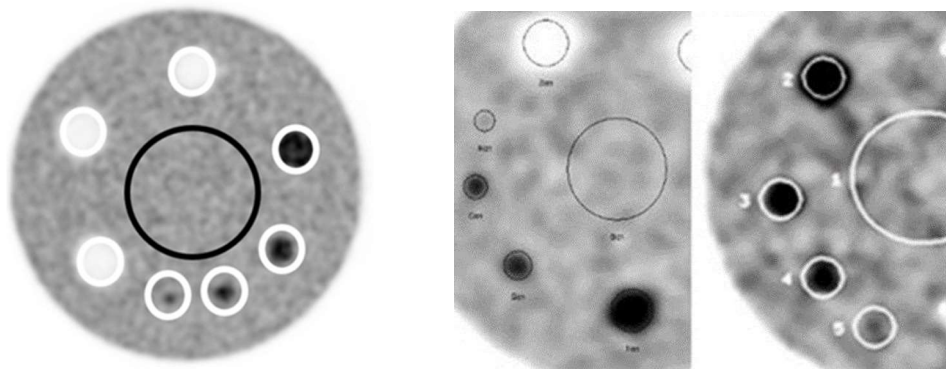
Example of a good phantom submission for PET – 2020 scanner:



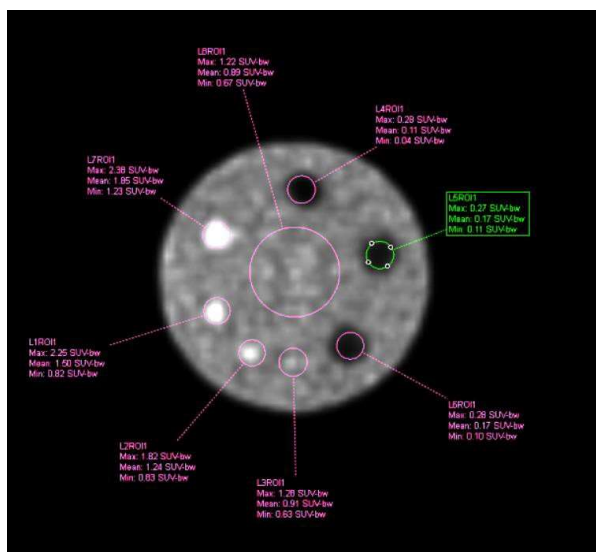
Images from 2011 scanner:



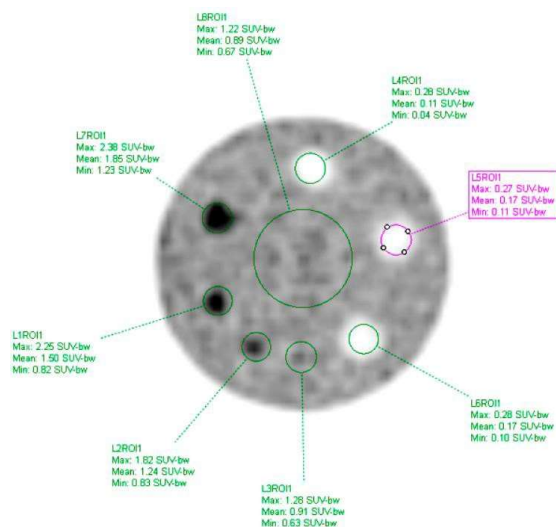
ROIs correctly drawn in the image on the left (example from the testing instructions). Outer ROIs should all be the same size as shown in the image on the very right. The middle image shows incorrectly drawn ROIs.



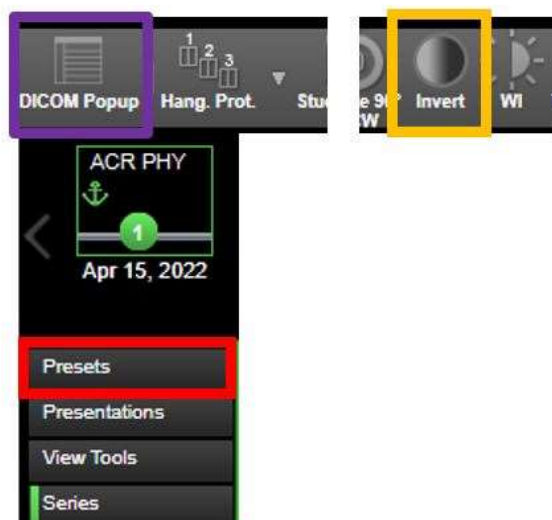
Image(s) of all 8 ROIs with SUVs displayed, must be included. Display should show Max, Min, and Mean values.



Images can be submitted as displayed above or inverted. If images uploaded are DICOM, reviewers can invert as necessary.



The toolbar will assist with ensuring correct images are included. If DICOM slice are uploaded, intensity may be adjusted using the **Presets** tool. The **DICOM Popup** may be helpful to check for slice thickness, counts, matrix. The **Invert** tool may be used by sites and reviewers to better view the images.



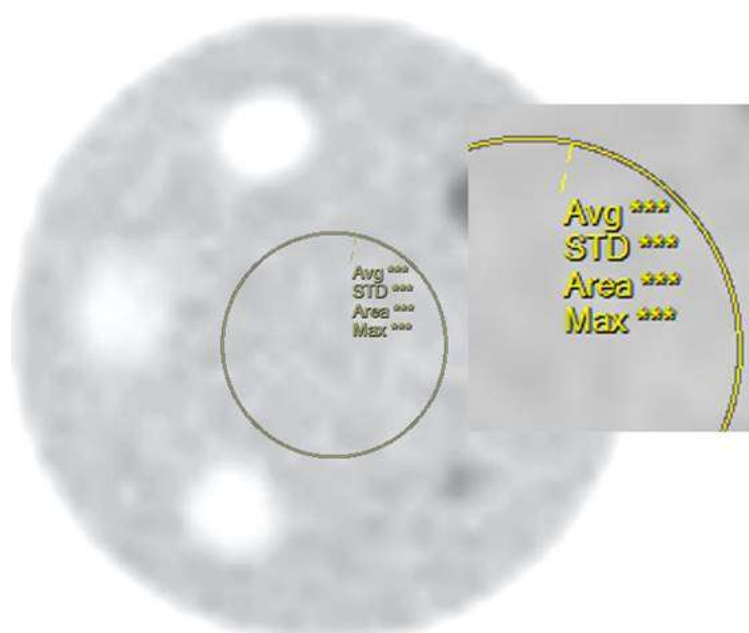
### **Additional Image Upload Instructions**

**\*The ACR uses NilRead Viewer for images uploaded for accreditation. The instructions below are in regard to using NilRead Viewer.\***

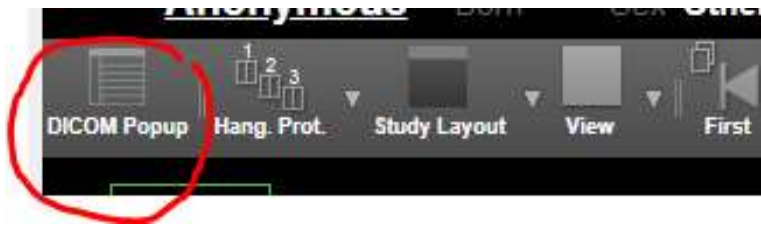
- To verify the file type is correct (DICOM) – draw an ROI after opening the file in the provided NilRead viewer (see the toolbar at the top of the NilRead viewer as shown in the image below).



- If the correct DICOM file type has been uploaded, the values seen in the NilRead viewer should be close to the data form entries. If SUV measurements are not seen (see example below), please contact your vendor applications or PACs/IT department for assistance, as the images are not in the correct DICOM format.



- When verifying slice thickness in NilRead viewer, click on the DICOM Popup tool in the upper left corner of the NilRead viewer toolbar to display the DICOM attributes and the slice thickness will be viewable (use CTRL F and word search “Thickness” to find the slice thickness).



DICOM Attributes			
(0000,0000)	EO	12	Manufacturer's Model Name
(0010,0010)	PN	10	Patient's Name
(0010,0020)	LO	14	Patient ID
(0010,0021)	LO	10	Issuer of Patient ID
(0010,0030)	DA	0	Patient's Birth Date
(0010,0040)	CS	2	Patient's Sex
(0018,0050)	DS	8	Slice Thickness
(0018,1010)	LO	8	Secondary Capture Device

- Slice thickness can also be verified in ACRedit Plus after the images have been uploaded (as seen in the image below). The phantom is 20cm in length. With the 1cm slice thickness requirement, the number of slices should be 20 (+/- 2).

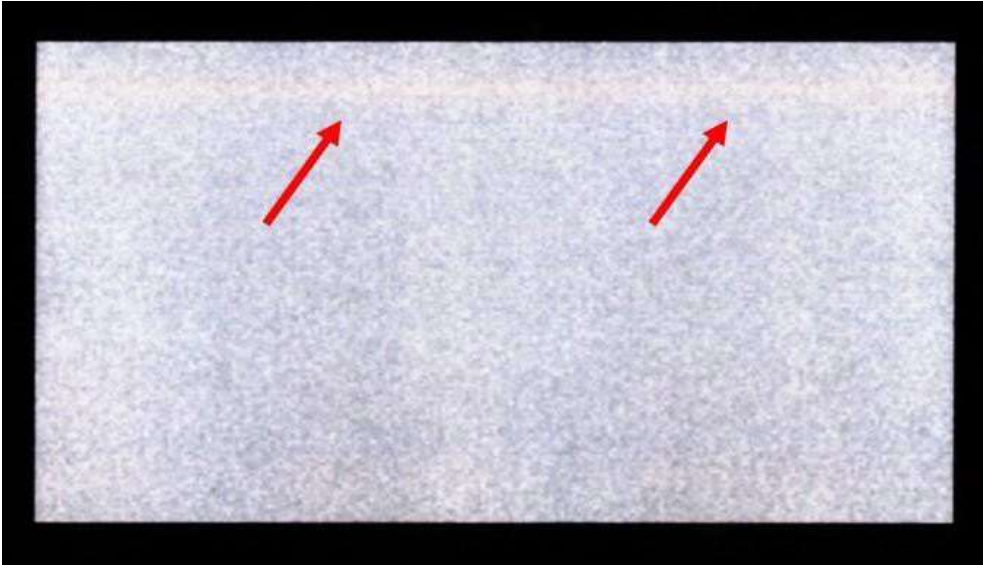
Type DICOM					<a href="#">View All DICOM Images</a>
Study Description			Study Date		
					<a href="#">✓ View Images</a>
Series Description	Number	Modality	File Size	Series Date	No of Files
	403	PT	15.77 MB		21

## Artifacts

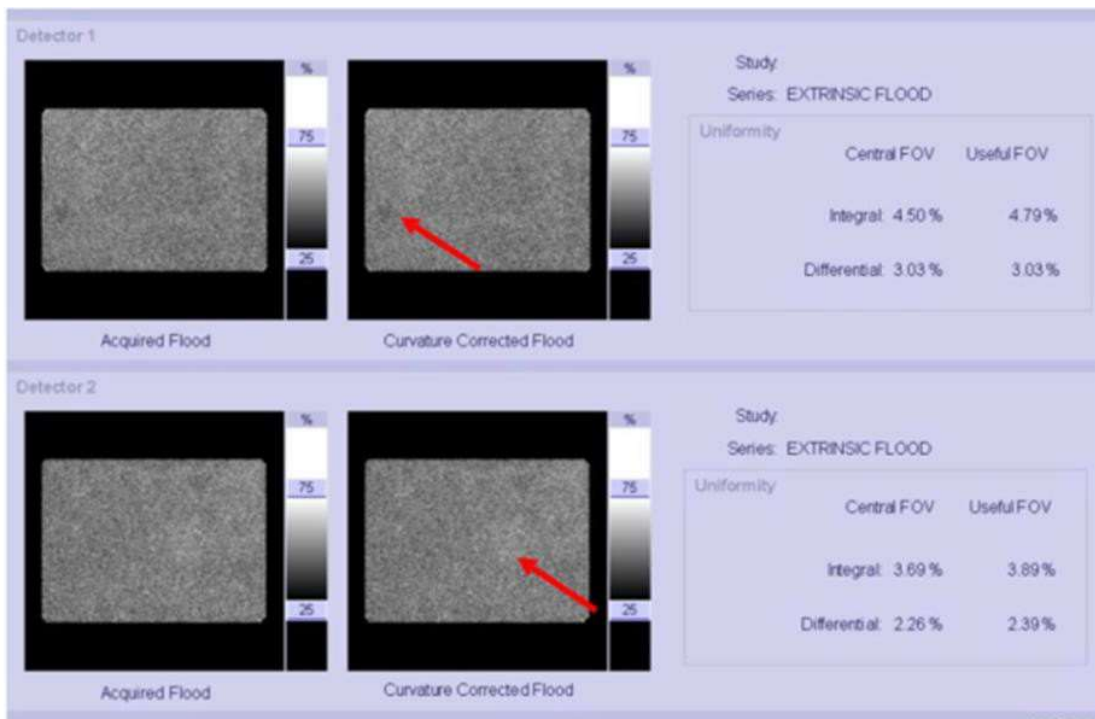
### Planar

**It is highly recommended to review the images with your physicist prior to submission.**

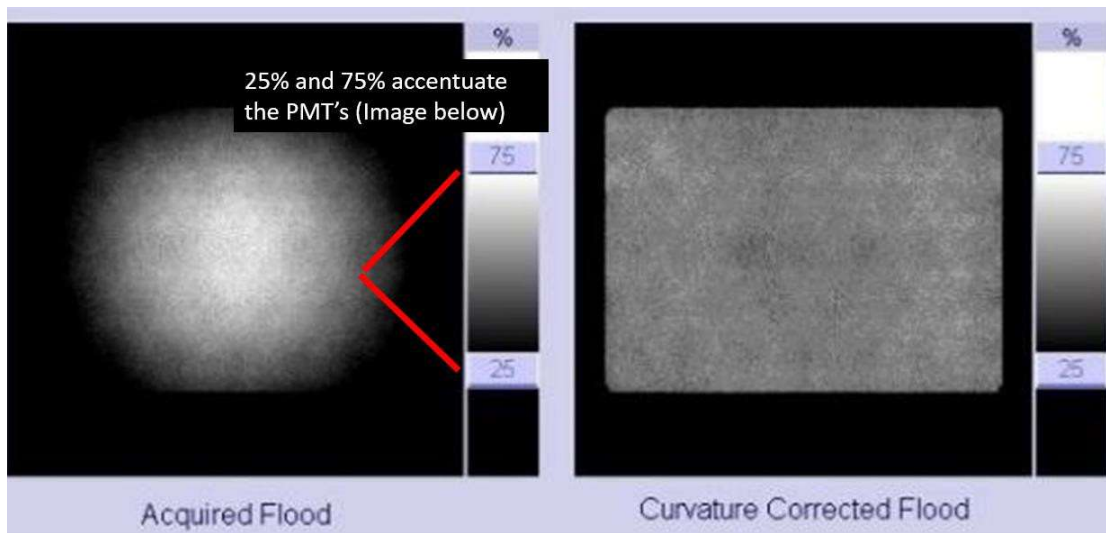
Poor paper print that was scanned and submitted as a jpg. The red arrows show an artifact on the paper printout that is accentuated when scanned as jpg.



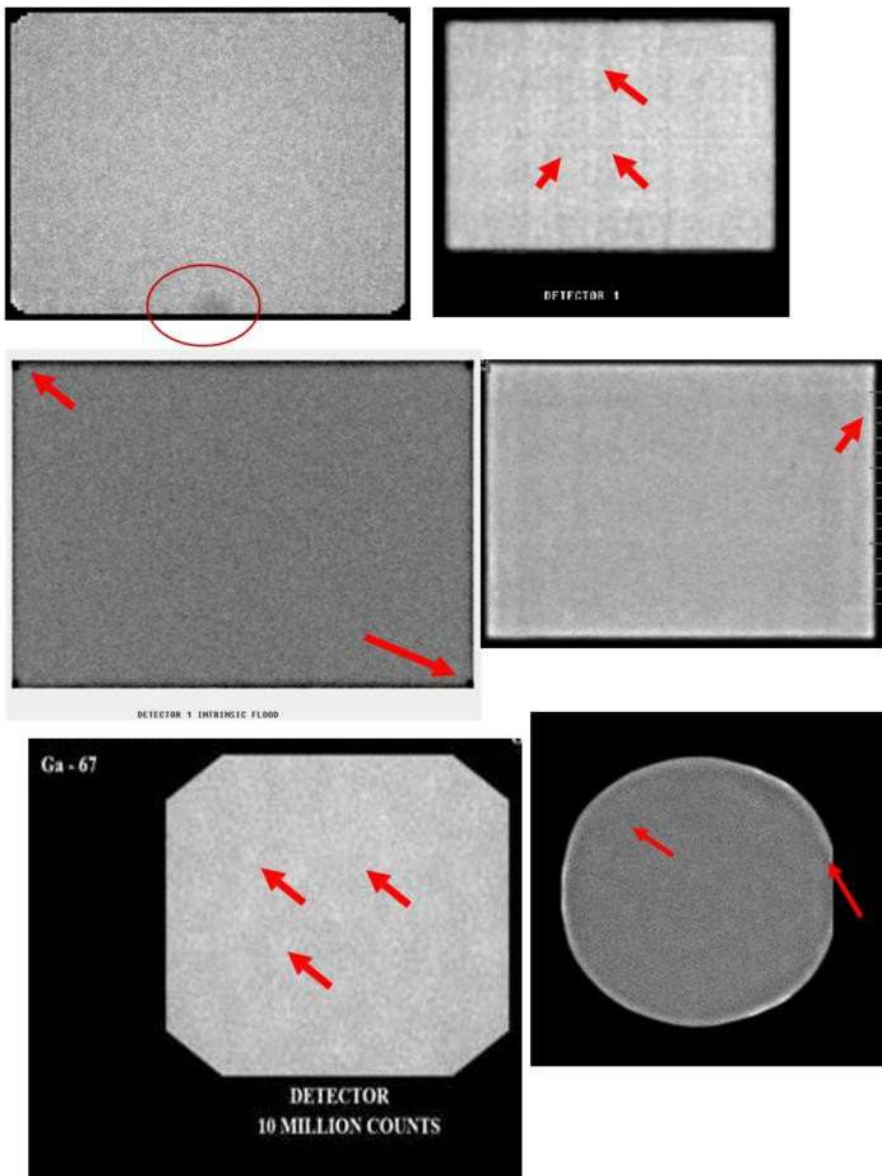
Gray scale set at 25% and 75% can adversely affect images.



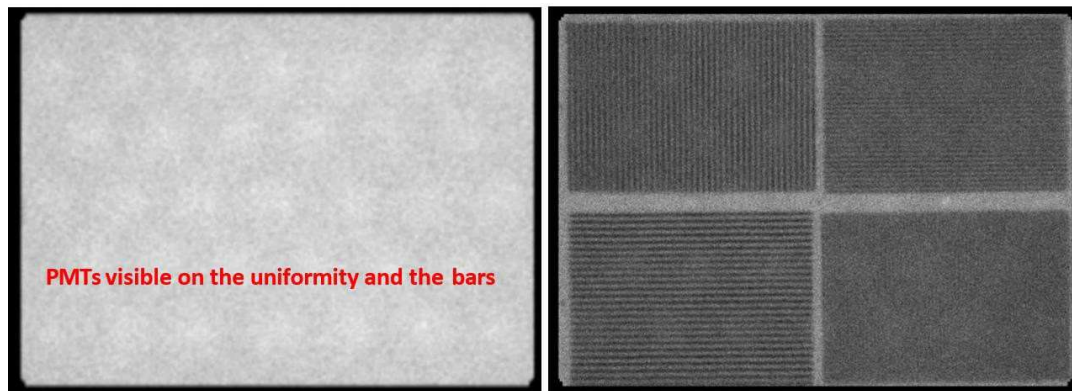
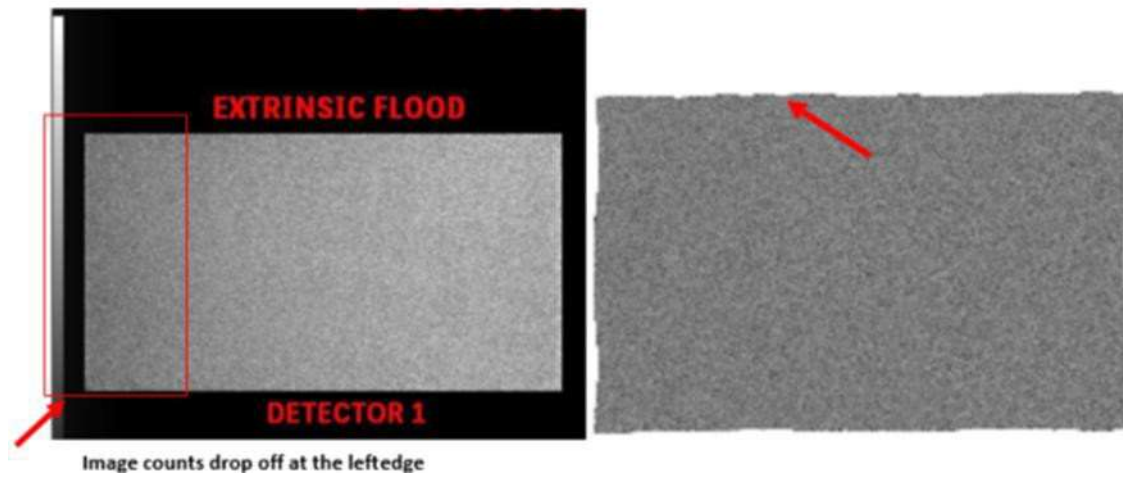




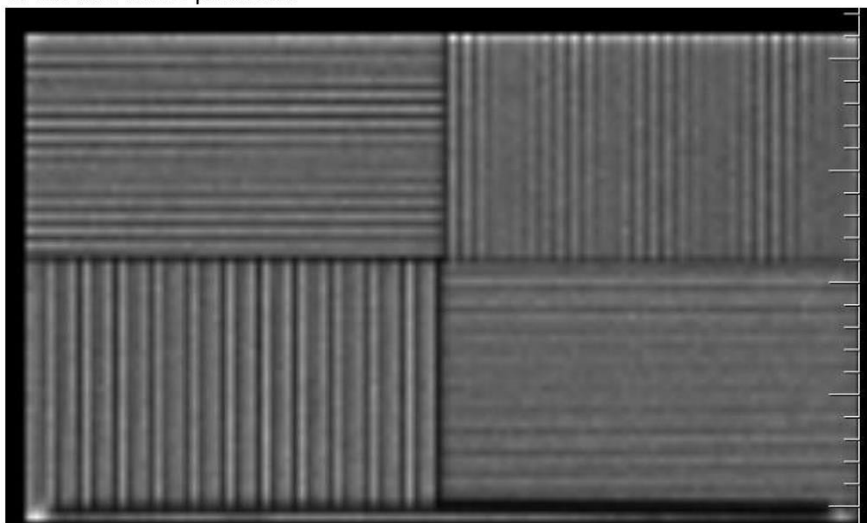
Red circle/arrows point to artifacts



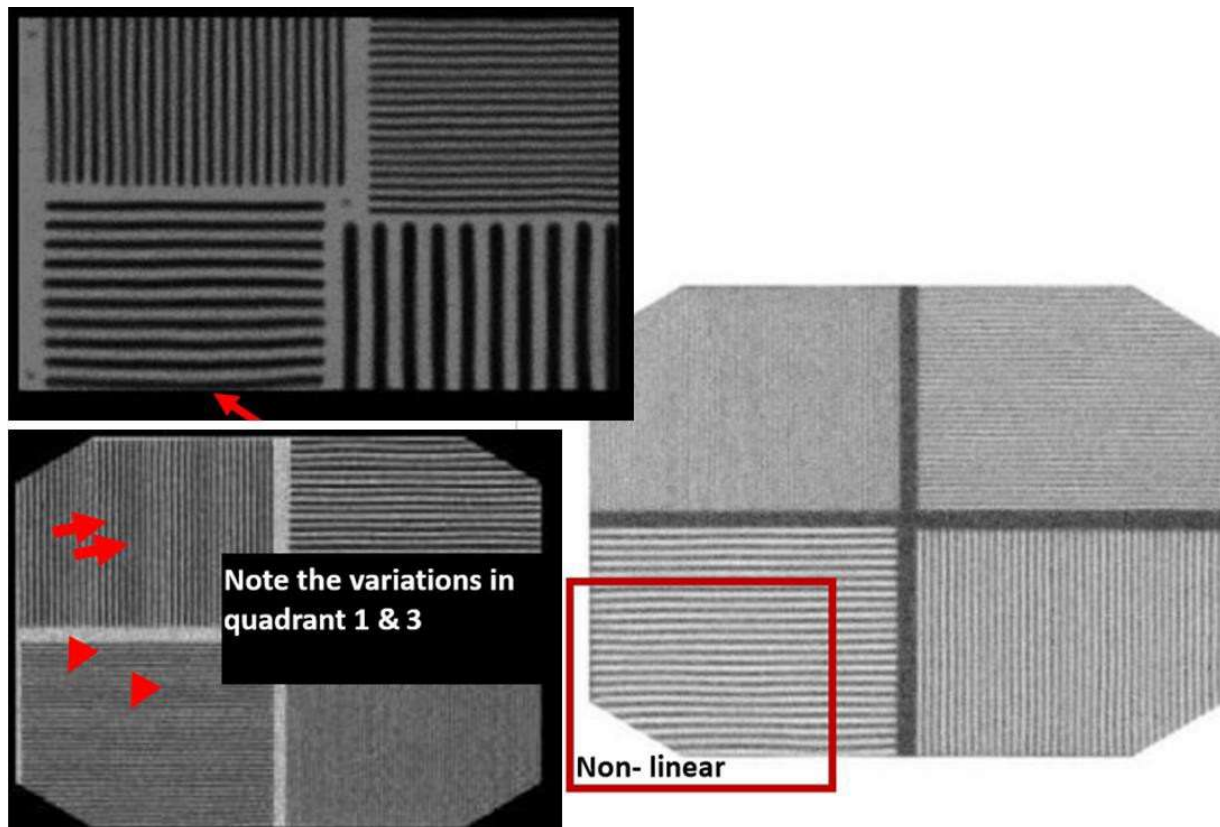




Example of aliasing. The pixel size for the acquisition is too large relative to the size of the bars in the phantom.



## Non-Linear artifacts



## SPECT

It is recommended to review the images with your physicist prior to submission.

Images showing poor masking and non-circular images.

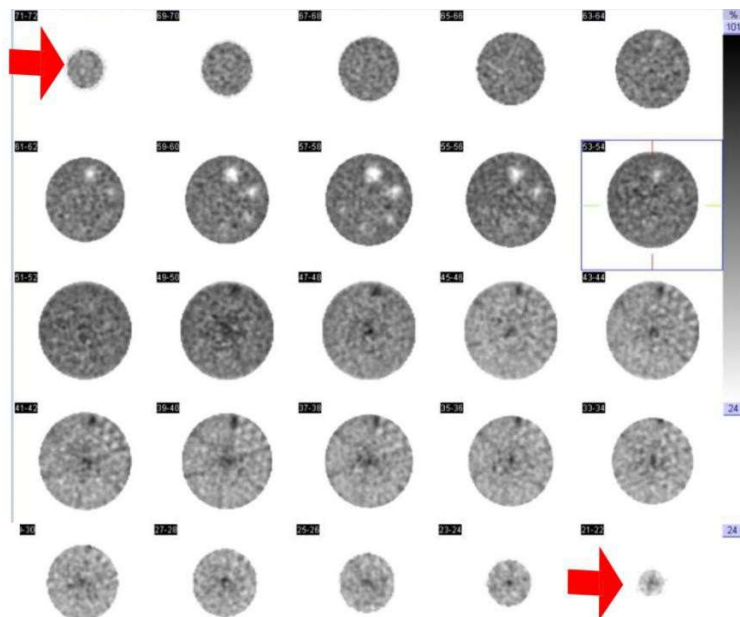
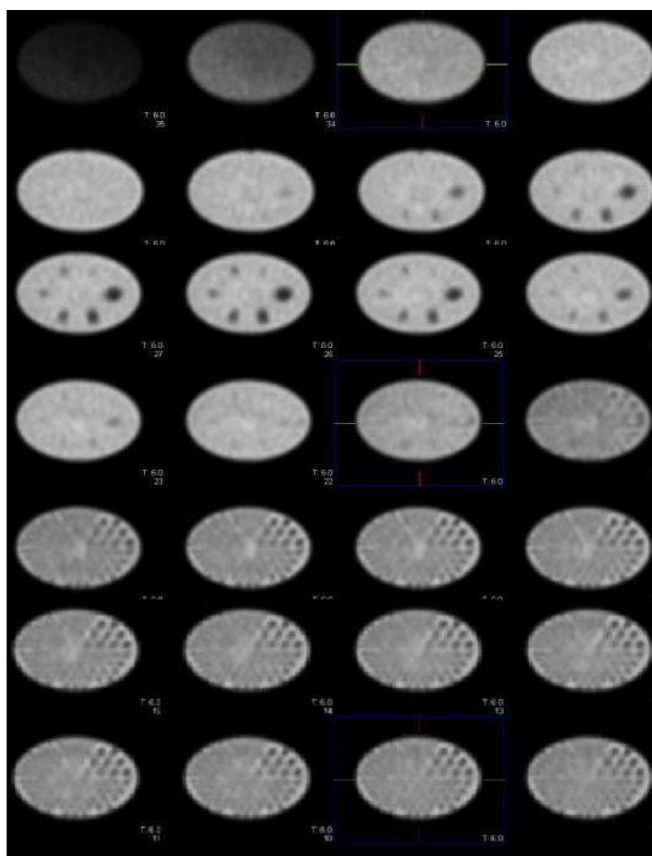
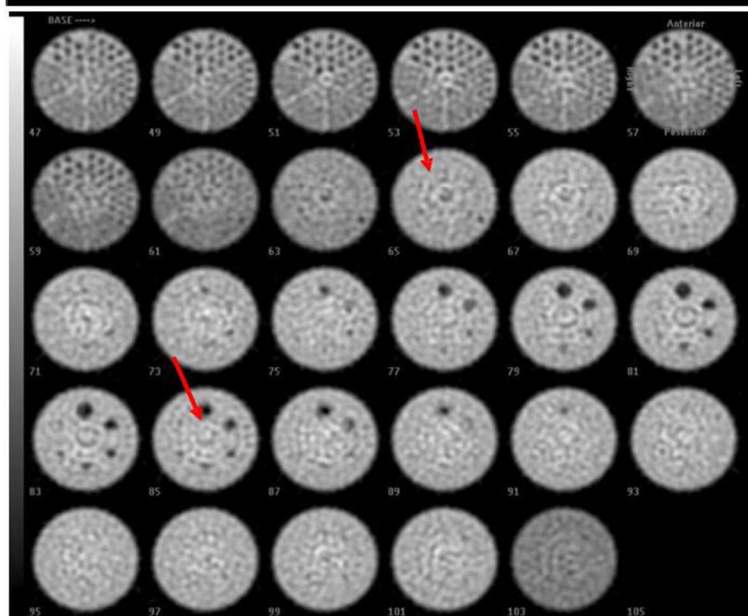
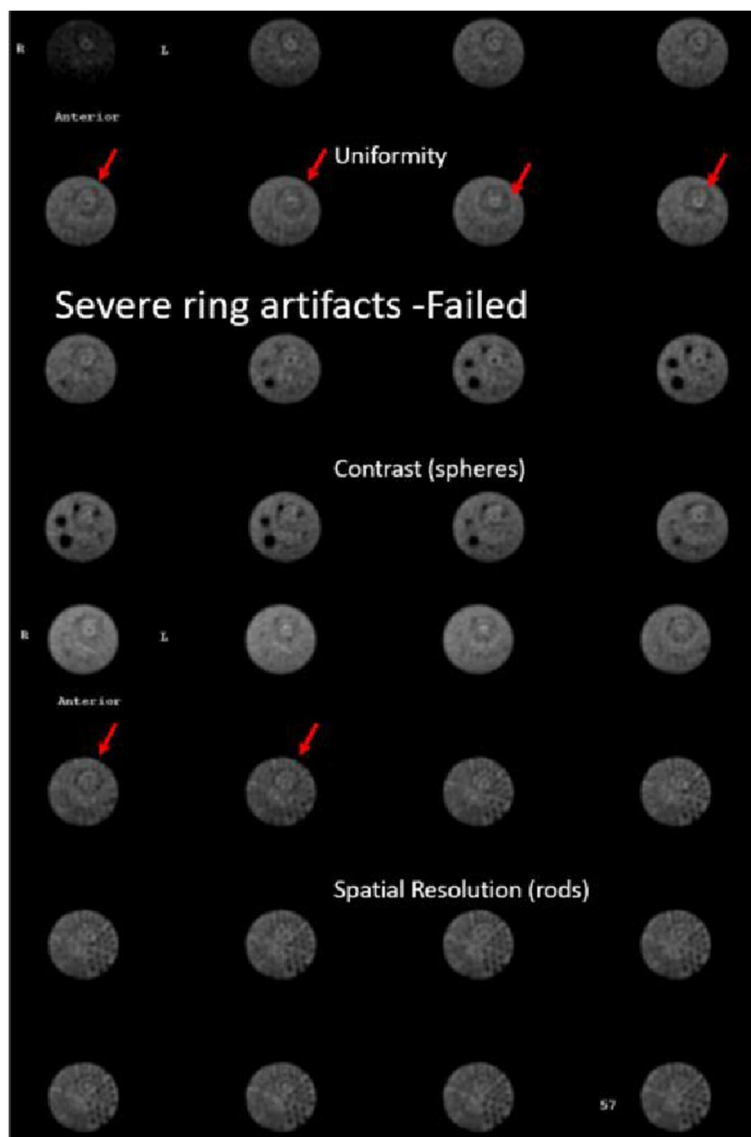


Image distortion



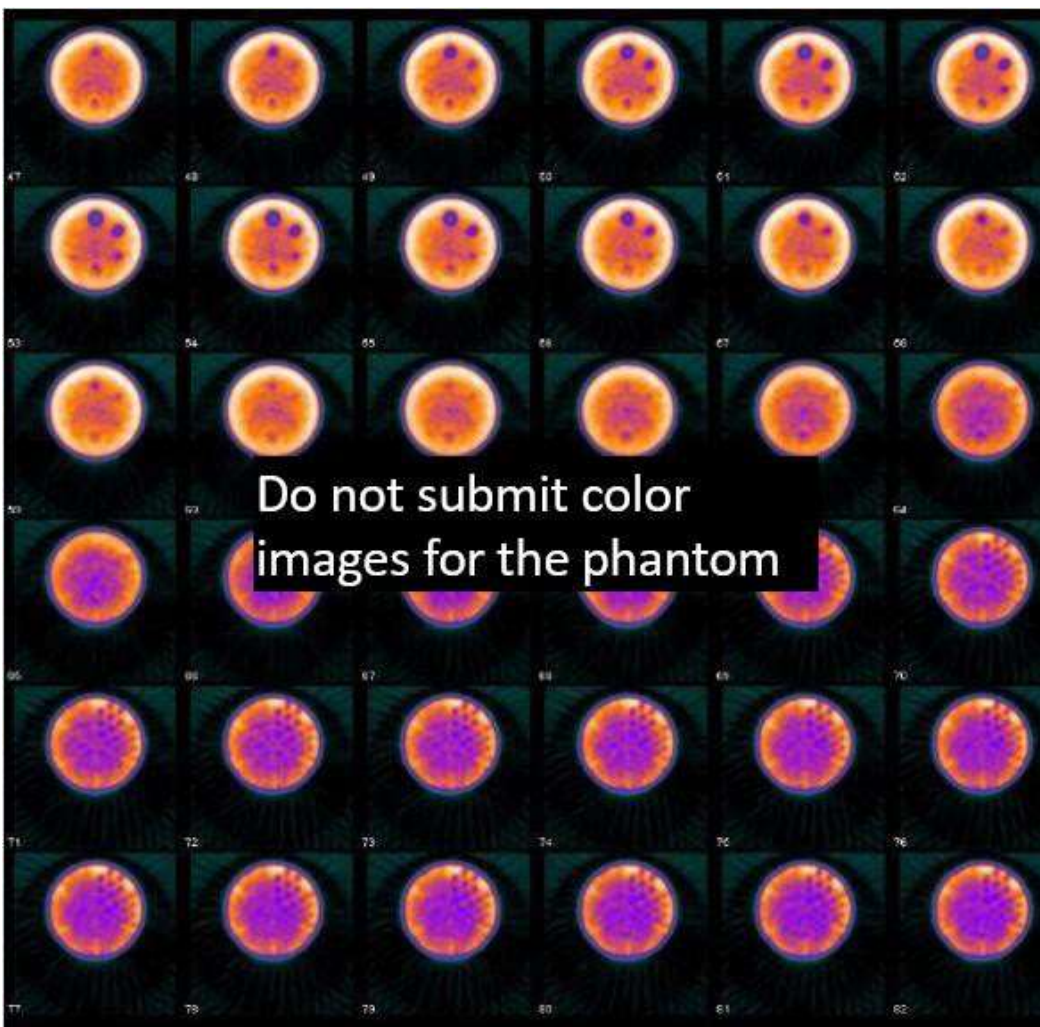
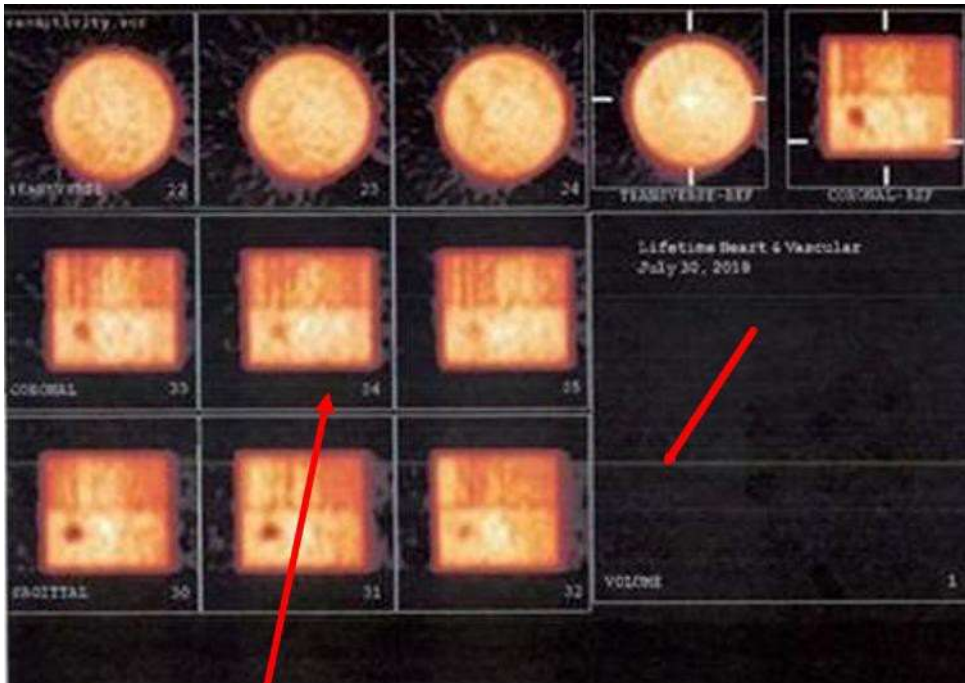
### Example of Bullseye ring artifact

It is always recommended that a new uniformity calibration and COR be acquired prior to the phantom acquisition.

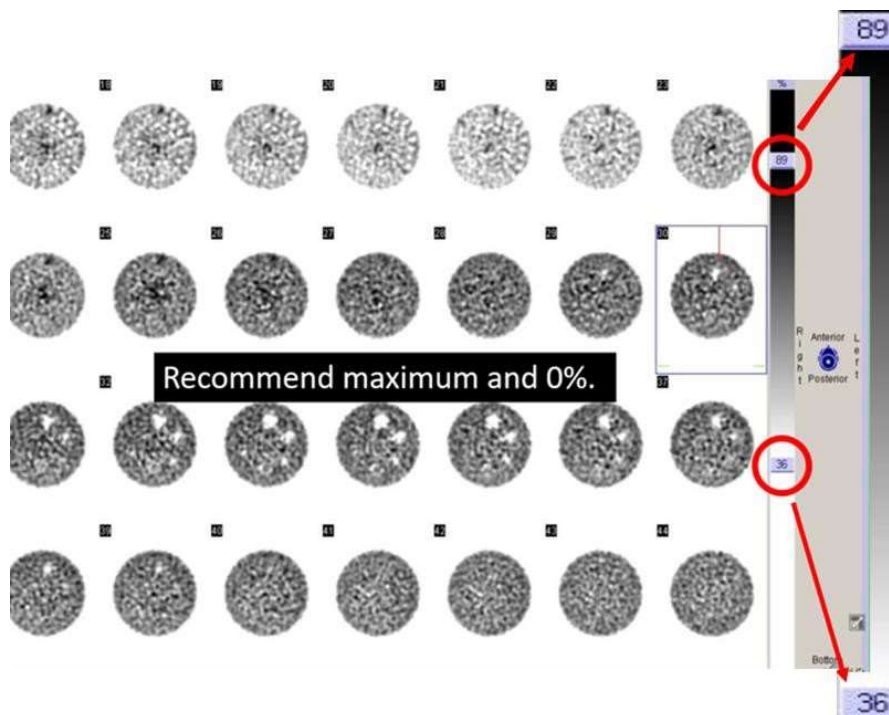
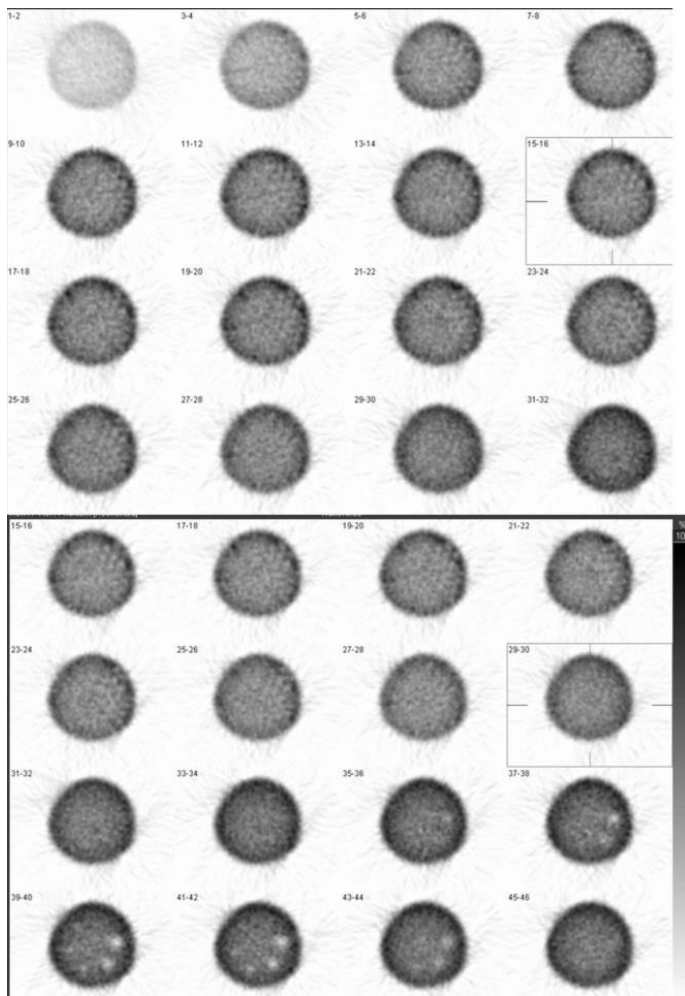




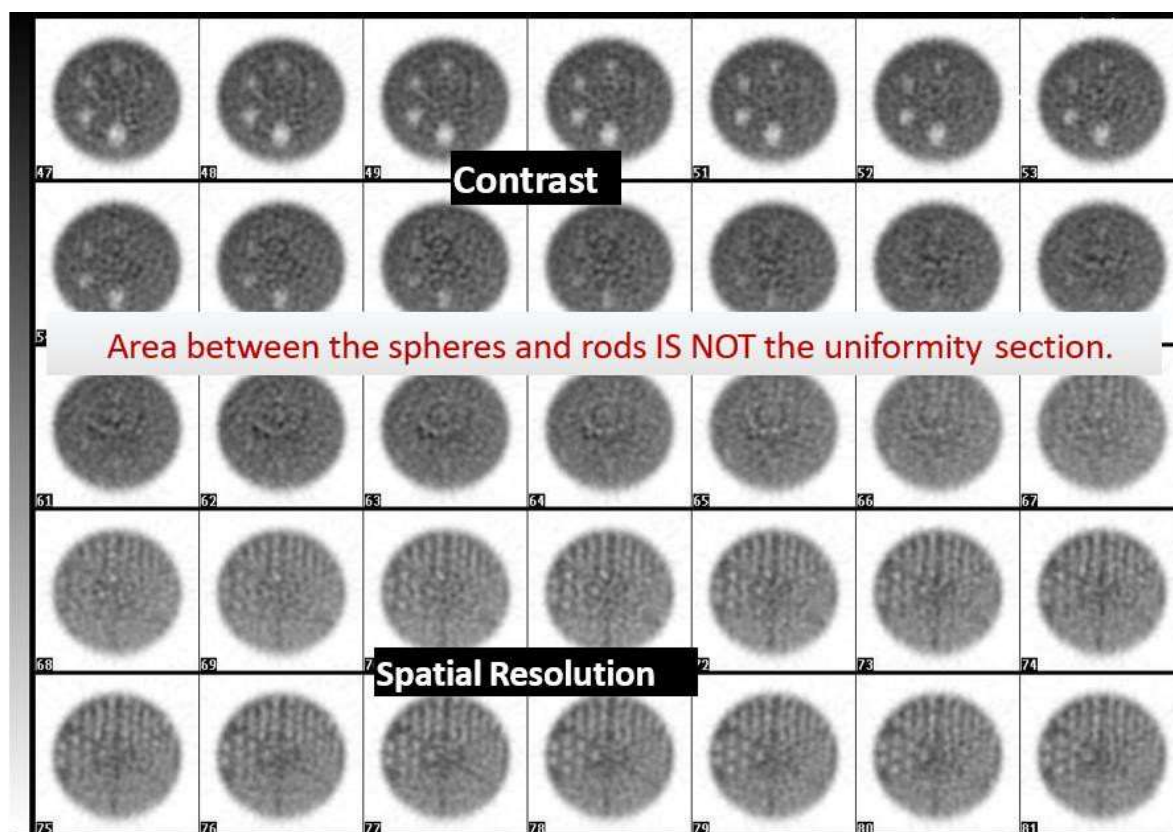
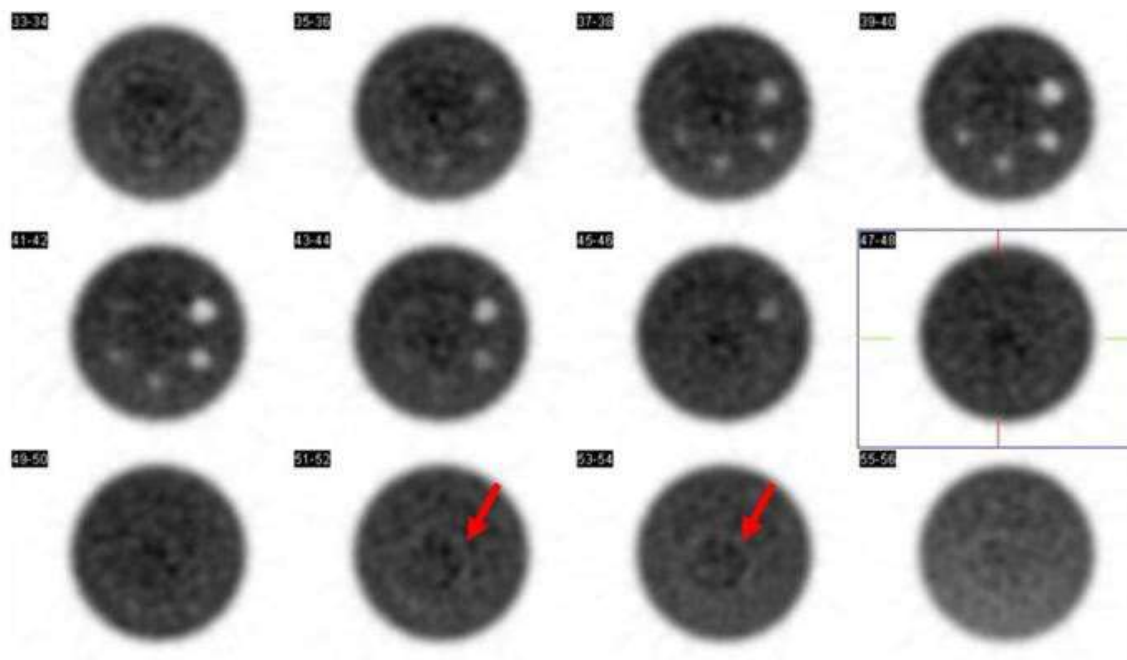
**Color images are not acceptable.** Additionally, please do not include raw data. Below is also an example of a poor color print or paper image scanned in to create a jpg for upload. This is not acceptable.



Non-circular image and lack of the rods section visualization resulted in failure.



Example below of a more moderate ring artifact also resulting in failure.

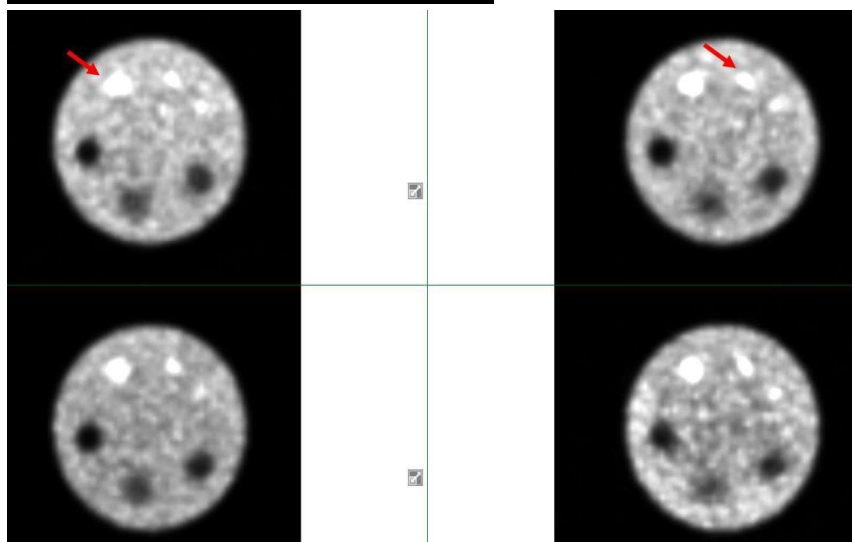
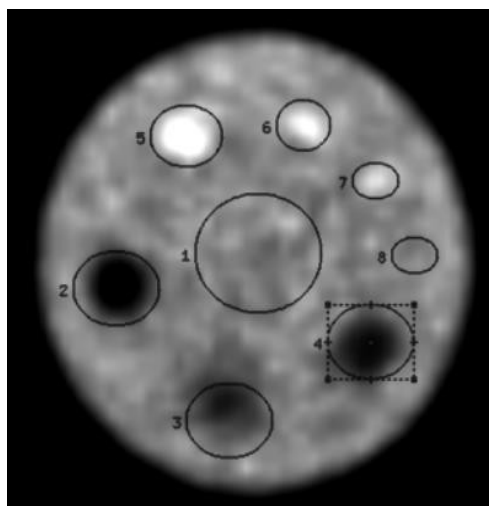
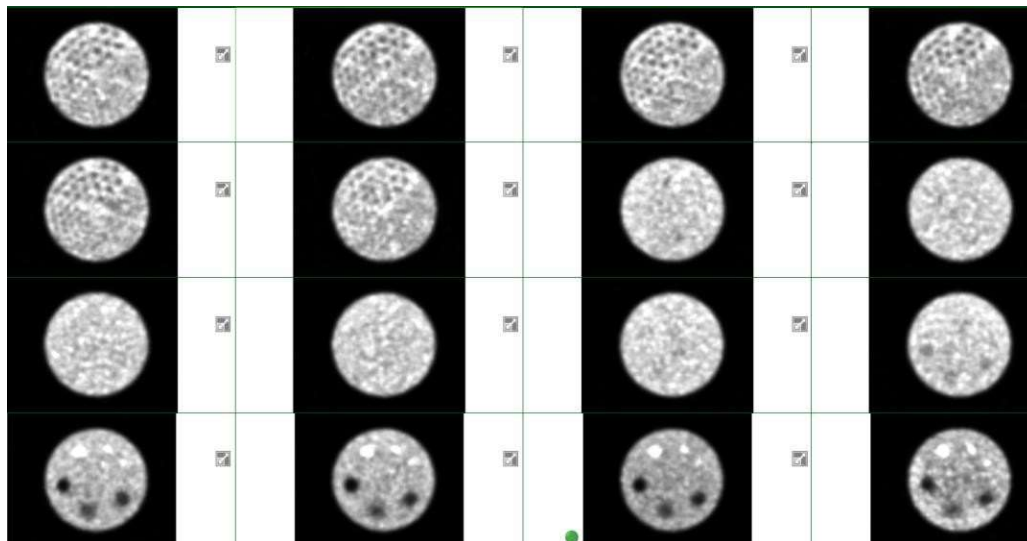




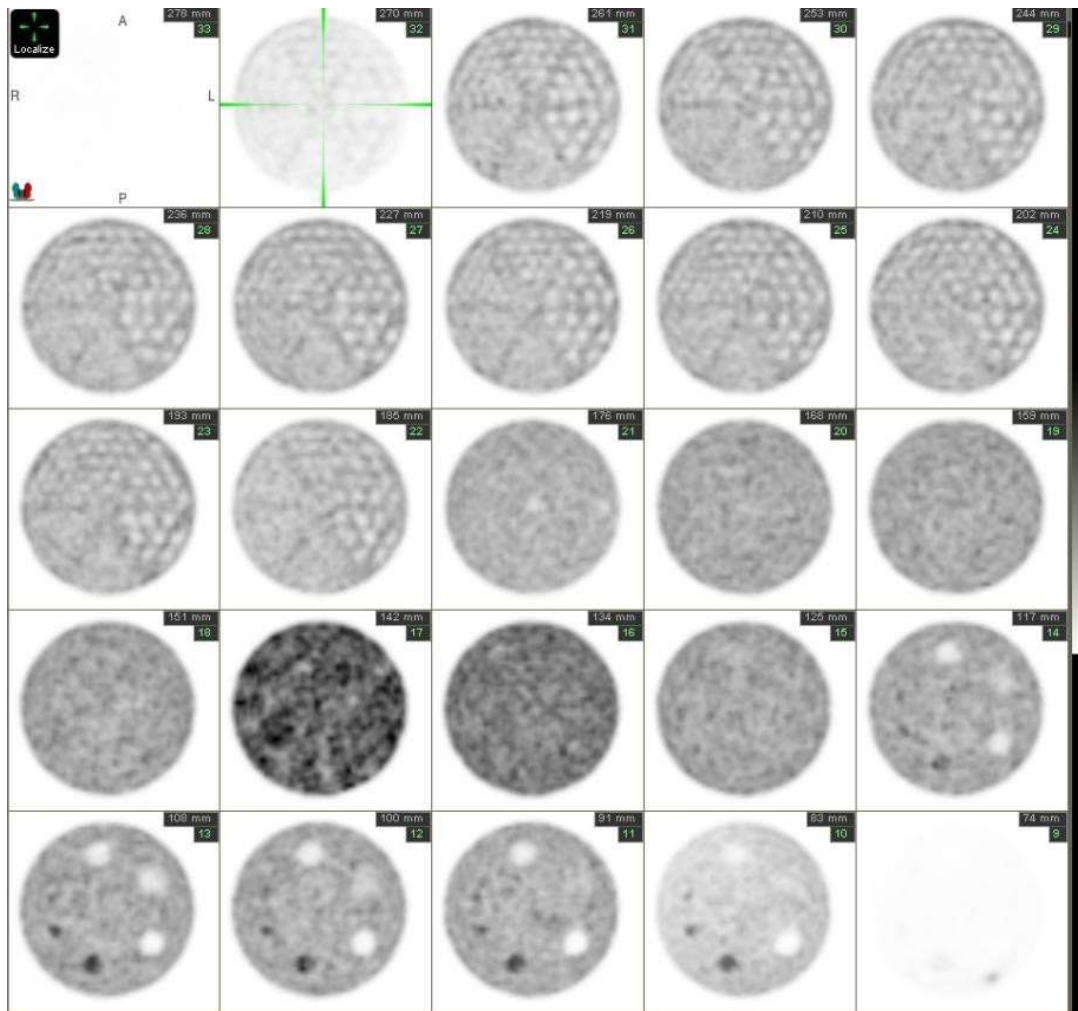
## PET

It is recommended to review the images with your physicist prior to submission.

Images below are quite noisy and the 16mm cylinder does not appear completely circular.



Images should be normalized to the series, not each frame. Images 17-18 are brighter than the rest of the series.



Poor spatial resolution displayed below. Only the largest rods are seen

