Technical Publication

Revision 3

Omni Legend

NEMA NU 2-2018 Test Procedures

and Detector Performance Test

Applicable to:

Omni Legend (32 cm FOV)

Omni Legend (16 cm FOV)

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DAMAGE IN TRANSPORTATION

Check for damage to property that may have occurred at the site during delivery, such as damage to floors, door frames or walls.

All packages should be closely examined at time of delivery. If damage is apparent, have the notation *Damage in Shipment* written on **all** copies of the freight or express bill before delivery is accepted or signed for by a GE Healthcare representative or a hospital receiving agent. Whether noted or concealed, damage MUST be reported to the carrier immediately upon discovery, or in any event, within 14 days after receipt, and the contents and containers held for inspection by the carrier. A transportation company will not pay a claim for damage if an inspection is not requested within this 14-day period.

To file a report, contact the local service coordinator for more information about this process

CERTIFIED ELECTRICAL CONTRACTOR STATEMENT

All electrical Installations that are preliminary to positioning of the equipment at the site prepared for the equipment shall be performed by licensed electrical contractors. In addition, electrical feeds into the Power Distribution Unit shall be performed by licensed electrical contractors. Other connections between pieces of electrical equipment, calibrations and testing shall be performed by qualified GE Healthcare personnel. The products involved (and the accompanying electrical installations) are highly sophisticated, and special engineering competence is required. In performing all electrical work on these products, GE Healthcare uses its own specially trained field engineers. All of GE's electrical work on these products will comply with the requirements of the applicable electrical codes.

The purchaser of GE Healthcare equipment shall only utilize qualified personnel (i.e., GE's field engineers, personnel of third-party service companies with equivalent training, or licensed electricians) to perform electrical servicing on the equipment.

IMPORTANT: X-RAY PROTECTION

X-ray equipment if not properly used may cause injury. Accordingly, the instructions herein contained should be thoroughly read and understood by everyone who will use the equipment before you attempt to place this equipment in operation. The General Electric Company, Medical Systems Group, will be glad to assist and cooperate in placing this equipment in use.

Although this apparatus incorporates a high degree of protection against x-radiation other than the useful beam, no practical design of equipment can provide complete protection. Nor can any practical design compel the operator to take adequate precautions to prevent the possibility of any persons carelessly exposing themselves or others to radiation.

It is important that anyone having anything to do with x-radiation be properly trained and fully acquainted with the recommendations of the National Council on Radiation Protection and Measurements as published in NCRP Reports available from NCRP Publications, 7910
Woodmont Avenue, Room 1016, Bethesda, Maryland 20814, and of the International
Commission on Radiation Protection and take adequate steps to protect against injury.

The equipment is sold with the understanding that the General Electric Company, GE Healthcare, its agents, and representatives have no responsibility for injury or damage which may result from improper use of the equipment.

Various protective materials and devices are available. It is urged that such materials or devices be used.

IMPORTANT: RADIOACTIVE MATERIAL HANDLING

Only employees formally trained in radioactive materials handling and this equipment are authorized by the GE Healthcare Radiation Safety Officer to use radioactive materials to service this equipment.

GE Healthcare Services is required to notify the applicable U.S. state agency PRIOR to any source service event involving calibration source handling. See NUC/PET Radioactive material guides for specific instruction or contact your EHS Specialist.

OMISSIONS & ERRORS

Customers, please contact your GE Healthcare Sales or Service representatives.

GE personnel, please use the GE Healthcare Trackwise system to report all omissions, errors, and defects in this publication.

REVISION HISTORY

Revision	Date	Reason for Change
1	Oct 10 2021	Initial release, based on Discovery-MI Gen2 NEMA NU2 – 2018 5860378-1EN
2	Mar 24 2022	Removal of Language policy, update of Damage in Transportation section, update of figures in all the sections, addition of length correction in Section 3, addition of optional CT scan in Section 2, update of patient information for Image Quality scan in Section4, update of performance specifications.
3	Jun 20 2022	Wording improvement in sections 1, 2, 3, 5, 6, correction of typos in sections 3, 4, update of Figure 2.3.

Section 1. Test Overview

NOTE: All performance testing presumes that the system is well tuned and has current corrections. The well counter and normalization corrections should be less than 2 weeks old. The gain calibration should be updated on the day of test. Correct any abnormalities observed during tuning or DQA, before testing.

Follow the procedures in this chapter to test Omni Legend series. All Omni Legend software releases contain the NEMA NU2-2018 processing tools. All performance measurements are evaluated per NEMA Standards Publication, NU2-2018, and Performance Measurements of Positron Emission Tomographs.

Table 1 and Table 2 summarize the requirements for each test, and provide a recommended timeline for executing the series. The activity levels listed in these tables are a guideline to estimate the total activity required. The actual activity at acquisition time is described in each section.

Table 1: Days 1 and 2 - Spatial Resolution, Sensitivity, Image Quality and PET-CT Co-registration test

Chapter Section and Test Title	Phantom, Isotope, Activity	Acquisition, Time, Disk Space	Analysis Process
Section 2 Spatial Resolution Page 12	Capillary Tubes, Support for tubes 0.1 cc F-18, with concentration > 150 MBq/cc (4.05 mCi/cc)	Via patient acquisition 1 hour	Recon images. Lower resolution images for positioning the sources, and higher resolution images for the resolution analysis. Use NEMA Analysis Tool to adjust position of the point sources and obtain table axial positions (center and 1/8th AFOV). The Tool also computes resolution results based on images.
Section 3 Sensitivity Test Page 25	NEMA Sensitivity Phantom, support for aluminum tubes 15 - 20 MBq (0.405 - 0.54 mCi) F-18	Via patient acquisition 1 hour	No recon. Use NEMA Analysis Tool to compute result from raw data at each radial position.
Section 4 Image Quality, Attenuation Accuracy & Scatter Correction Test Page 36	NEMA Image Quality phantom, NEMA scatter Phantom. 370 MBq (10 mCi) F-18	Via patient acquisition 20 minutes per replication (3 replications recommended) 63 Mbyte per replication	Recon images. Requires recent, good quality normalization and well counter correction. Use NEMA Analysis Tool to compute result.

Chapter Section and Test Title	Phantom, Isotope, Activity	Acquisition, Time, Disk Space	Analysis Process
Section 7 PET-CT Co-registration accuracy Page 58	NEMA PET-CT Co-registration phantom holder Hollow spheres: 17, 22 and 28mm	Via patient acquisition 20 minutes	Recon images. Requires recent, good quality normalization and well counter correction, and good quality VQC. Use NEMA Analysis Tool to

Table 2: (Night 1) 3D Scatter Fraction, Count Losses and Randoms and Timing Resolution Test

Chapter Section and Test Title	Phantom, Isotope, Activity	Acquisition, Time, Disk Space	Analysis Process
Section 5 Scatter Fraction, Count Losses, and Randoms Measurement Page 48	NEMA Scatter Fraction Phantom At least 800 - 850 MBq (21.6 – 23.0 mCi) F-18	3D: via patient acquisition up to 12 hours 100 GB	No recon. Use the NEMA Analysis Tool to compute result from raw data.
Section 6 Accuracy: Correction for Count Losses and Randoms Page 56	None: Uses data from Scatter Fraction, Count Losses, and Randoms Test	Uses data from Scatter Fraction, Count Losses, and Randoms Test	Recon 128x128 images. Use NEMA Analysis Tool to compute result based on images. Peak NECR activity value is required for calculation.

NOTE: You have the option to print a hard copy of the NEMA Analysis Tool results or save them in different formats with the "Save As" feature.

1.1 Log file with results from NEMA test

The engineering team at GEHC would appreciate receiving a copy of the log file generated by the NEMA analysis tool. This information will be combined with similar data from other scanners with the purpose of better understanding the variability of these measurements. The log file can be found under */usr/g/service/state/pet_mfg_NEMA.log*. Please send a copy of the log file as an attachment to your field engineer or clinical applications specialist, with instructions to forward the file to the PET engineering team.

The following steps show how to copy the NEMA log file into a memory thumb drive:

1. insert drive into the USB port in the front of the console's computer or in the USB port in the DVD external tower.
2. Open a Linux terminal window by clicking on the *Tool Chest* button and selecting Unix Shell – L/R.
3. Type *mountUSB*
4. Type *cd /USB*
5. Type *cp /usr/g/service/state/pet_mfg_NEMA.log***.** (notice the period at the end of the copy command).
6. Type *cd*
7. Type unmountUSB
8. The memory drive can be unplugged now and inserted into a computer with e-mail connection for transfer to PET engineering.

1.2 Table Characterization Check (a pre-requisite to all NEMA tests):

It is recommended that prior to the start of NEMA testing the system is checked for proper table characterization. This is to be done to make sure that the table elevation is within the specified accepted range. The standard procedure followed at site for the table characterization during the installation of the system includes the measurement of the distance from the laser alignment light to the top of the table when the table is at its maximum elevation. This value should read between 4 mm and 8 mm and the value should be displayed on the gantry display. In order to verify that proper table characterization is in place, follow the below steps:

1. Move the table base to the CT position.
2. Remove any holder from the end of the table and pull back the padding from the table.
3. Elevate the cradle to the maximum height and move it close to the CT FOV.
4. Turn on lasers.
5. Measure the distance from the top of the cradle (at the lowest point) to the laser line using a ruler as shown the Figure 1.1 (left).
6. The measured value should be between 4 and 8 mm and should match the tablet display on the gantry for the table elevation as shown in Figure 1.1 (bottom). If this condition is not met, ask FE to re-characterize the table height from ISO.

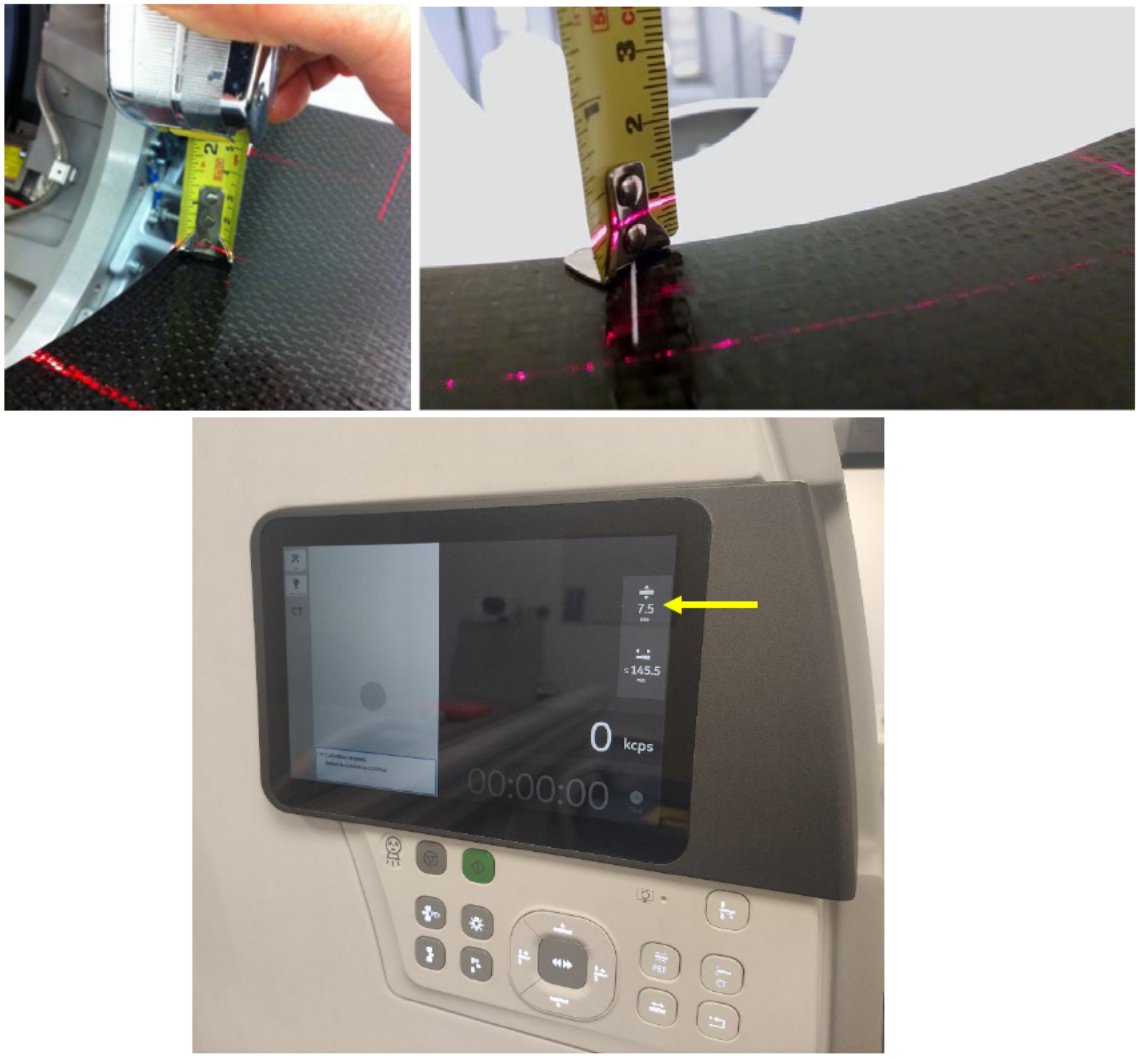


Figure 1.1: Table characterization check

Section 2. Spatial Resolution

The spatial resolution of a system represents its ability to distinguish between two points after image reconstruction.

2.1 Prepare the Hematocrit Capillary Tubes

NOTE: For best results, add a small amount of concentrated dye to the activity, to enhance visibility of the drops you make and draw during this procedure.

1. Refer to Figure 2.1. Use a new syringe to place samples of F-18 with >200 MBq/cc (5 mCi/cc) activity concentration on a slide.

NOTE: Refer to Figure 2.1. For best results, tap the tip of the syringe against the surface in ten or twelve different places, then choose 3 samples of equal size to use.

Figure 2.1: Tap the Tip of the Syringe to Make Equal Sized Drops

2. Place one end of a capillary tube (gauge 21) onto one of the drops. The capillary action draws the drop into the tube.

NOTE: The prepared point sources must be less than 1 mm in axial length. If the source is longer than 1 mm, the measured axial resolution will increase proportionately.

3. Refer to Figure 2.2. Verify the drop fills less than 1 mm of the capillary tube. If the fill length exceeds 1 mm, discard the tube and try again.

4. Refer to Figure 2.2. Press each end of the tube into the clay to seal it. First, seal the end of the tube with activity. When plugging the capillary, plunge the tube straight into the clay and all the way to the tray bottom to guarantee all three point sources are same distance from the end of the tube.
5. Repeat the process to make three sources.

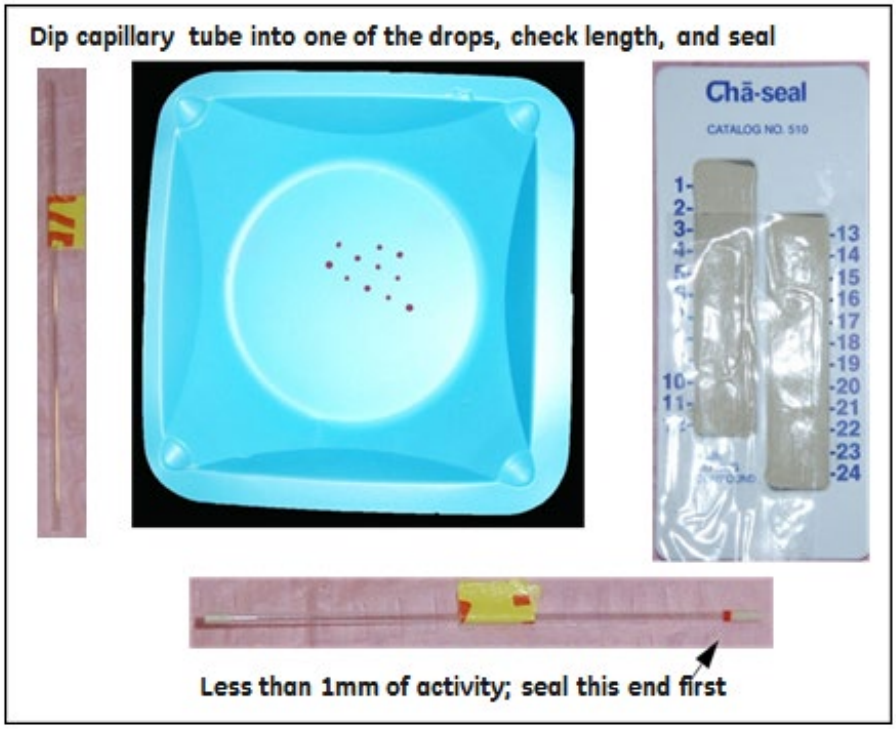


Figure 2.2: Fill and seal the capillary tubes

2.2 Position the Source and Acquire the Position Check Scan

NOTE: Refer to Figure 2.3. For data processing to execute correctly, position all three point sources in the specified locations. For best results, use the source holder (Fixture 5384787-12) to hold the capillary tubes in the exact locations.

1. Refer to Figure 2.3. Turn all the white plugs into the holding plate until thread bottoms out – do not tighten them. Gently insert one F-18 point source into each white plug. Push each of the tubes containing the source all the way into the plugs until the end of the capillary opposite to the point source reaches the bottom of the hole in the supporting plug.

- PS#1: x = 0 mm and y = -10 mm
- PS#2: x = 0 mm and y = -100 mm
- PS#3: x = 0 mm and y = -200 mm

2. Refer to Figure 2.3 and Figure 2.8:
   a. Slide the Phantom Holder into the accessory slot in the front of the cradle until it latches into place.
   b. Slide the Fixture 5384787-12 source holder bracket over the top of the Phantom Holder and align the edges of the source holder's bracket to the edge surfaces of and the Phantom Holder.
   c. Turn the X and Y knobs to center the holder to the X and Y graticules.
   d. Turn the Tilt knob until the Phantom Holder appears parallel to the scan plane.

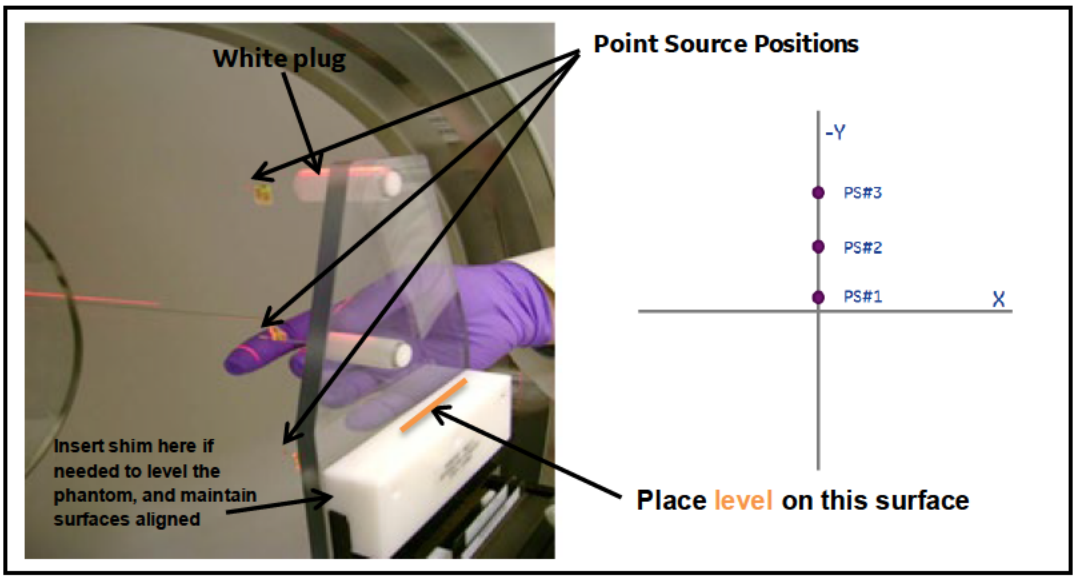


Figure 2.3: Point Source Positions, as Viewed from the Table Side of the Gantry.

3. Refer to Figure 2.3. Press the alignment light button and move the cradle into the CT scan FOV until the lasers at the CT image plane illuminate the active spot of all three point sources simultaneously.
   - Adjust table height, cradle position and X and Y knobs to align the point sources to the vertical laser. Use the scribed line at the bottom of the holder to align it to the horizontal laser as shown in Figure 2.4. Make sure that the laser and the scribe line are well aligned.
   - Adjust the pitch knob so that the phantom holder is aligned (along the side of the plate) with the vertical laser as shown in Figure 2.5.
   - Place a level on the white clamp as shown in Figure 2.5. If required, add thin shims under the clamp to adjust the level on the respective side.
   - Adjust X-direction by aligning the top capillary with the coronal laser.

4. Move the table to align all the point sources with the axial laser and press the INTERNAL LANDMARK button.

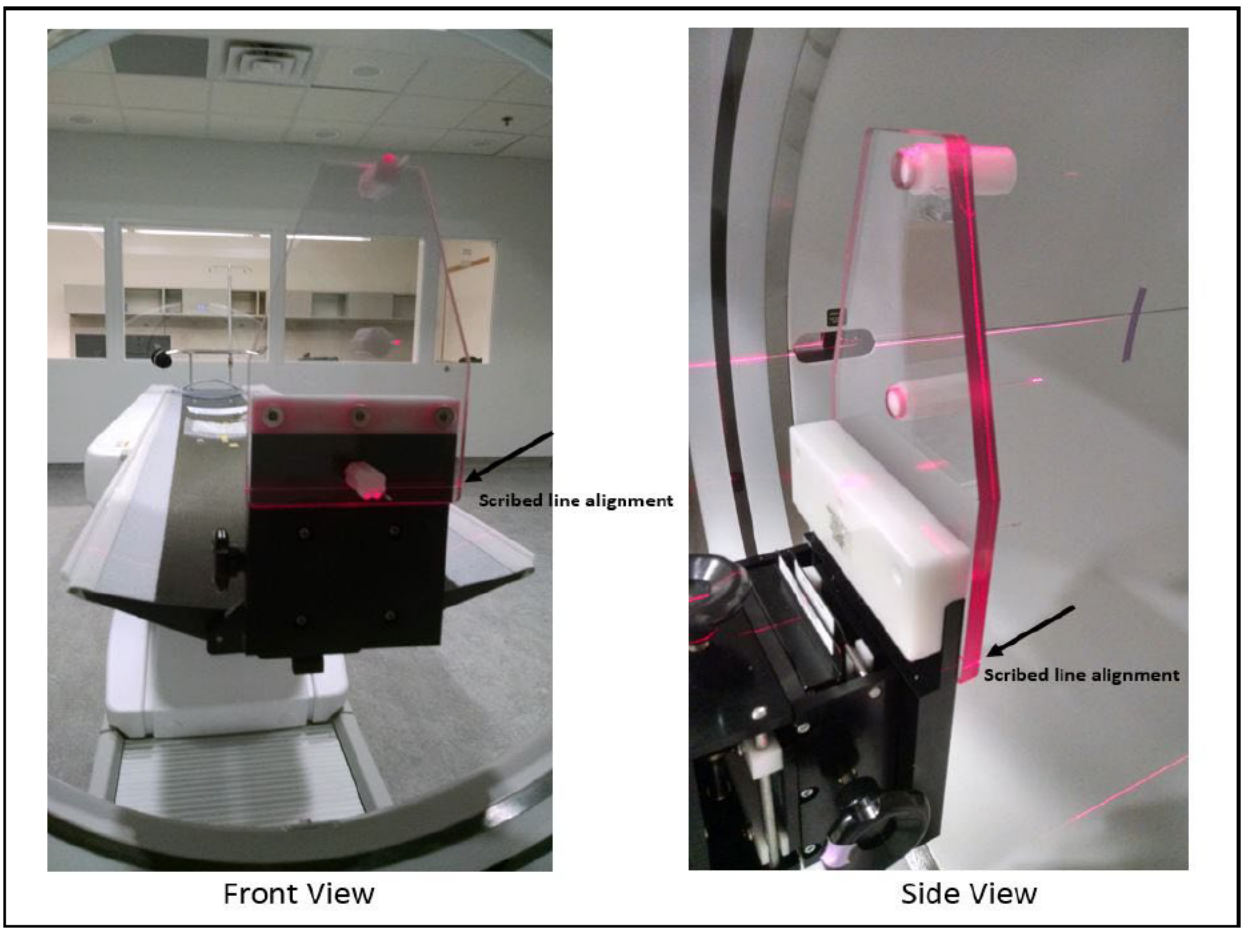


Figure 2.4: Scribed line alignment with the horizontal laser.

5. Click NEW PATIENT to open the Patient Information screen.
6. Type/enter a Patient ID and Patient Name into the corresponding data fields to activate the Protocol Selection area.
   • Use an easily identifiable name, such as NEMA Spatial Res.
7. If necessary, click the GE tab to select it.
8. Click beneath the Patient icon feet to display the Miscellaneous Protocol List.
9. Click the NEMA Resolution protocol description to open the View/Edit screen.
10. Click PET to display the PET acquisition view/edit screen.
    - This NEMA test does not require a CT scan, but if you would like to measure spatial resolution with Q.Clear reconstruction then CT scan is necessary.

NOTE: For best results, click on the first group of image parameters, then click INSERT SCAN two or more times to insert duplicate sets of the first group of scan parameters beneath the initial set, in case you have to reposition and rescan the point sources. Click DELETE SELECTED SCAN to delete any unused scan sets once you correctly position the point sources.

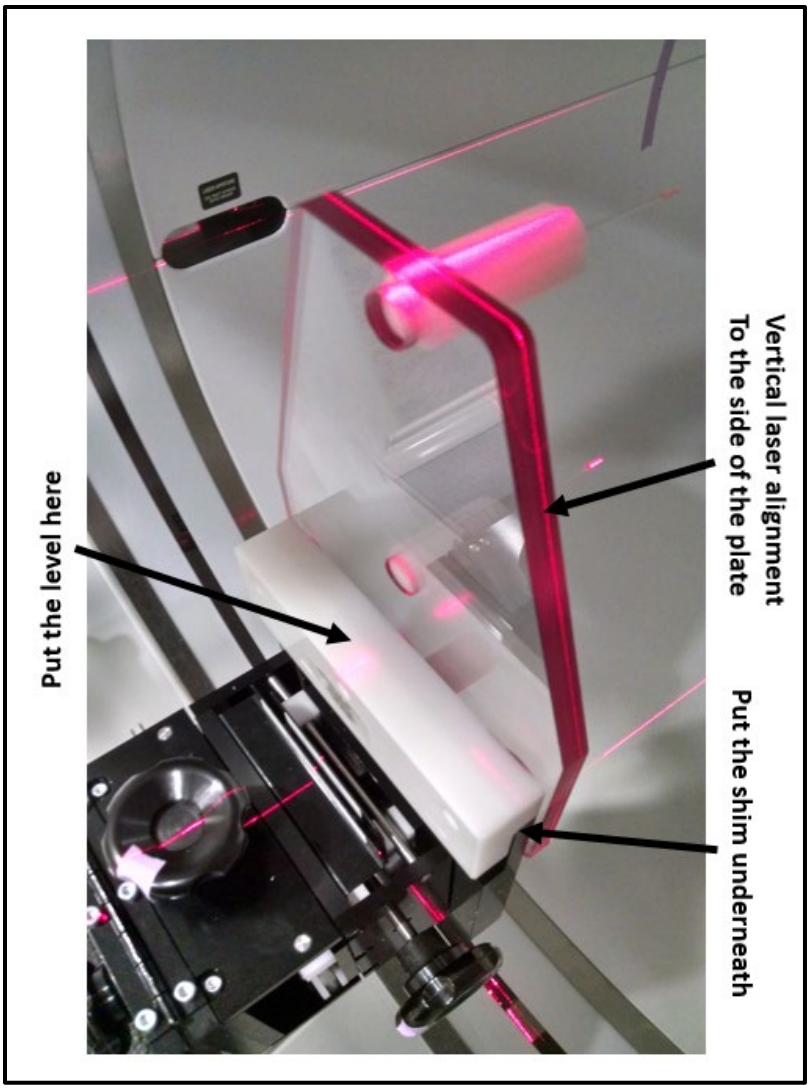


Figure 2.5: Vertical laser alignment.

11. If necessary, type/enter an identifying description into both the Scan Description and Series Description data fields. You may type the same description in both fields.
12. Select the first set of PET acquisition parameters, then click Insert scan 3-5 times. These scans might be useful for accurate positioning process.
13. Select the first set of PET acquisition parameters, then click CONFIRM.
    • Use the first set of scan parameters to check the position of the point sources.
14. If necessary, press the MOVE TO SCAN button when it flashes.
15. Press the START SCAN button when it flashes to initiate the one-minute data acquisition.
16. Upon completion of the first position check scan, proceed to Section 2.3 to check the position of the point sources.

2.3 Check the Position of the Point Sources in the SFOV

1. Click the SERVICE icon to display Common Service Desktop (CSD).
2. If necessary, click the PET radio button to display the PET CSD.
3. Click the IMAGE QUALITY icon to open the corresponding tab.
4. Click NEMA ANALYSIS TOOL to display the PET Analysis Tool shown in Figure 2.6.
   • If necessary, click the NEMA TESTS tab. (The UTILITY CALCULATIONS tab contains manufacturing tests not used during NEMA testing.

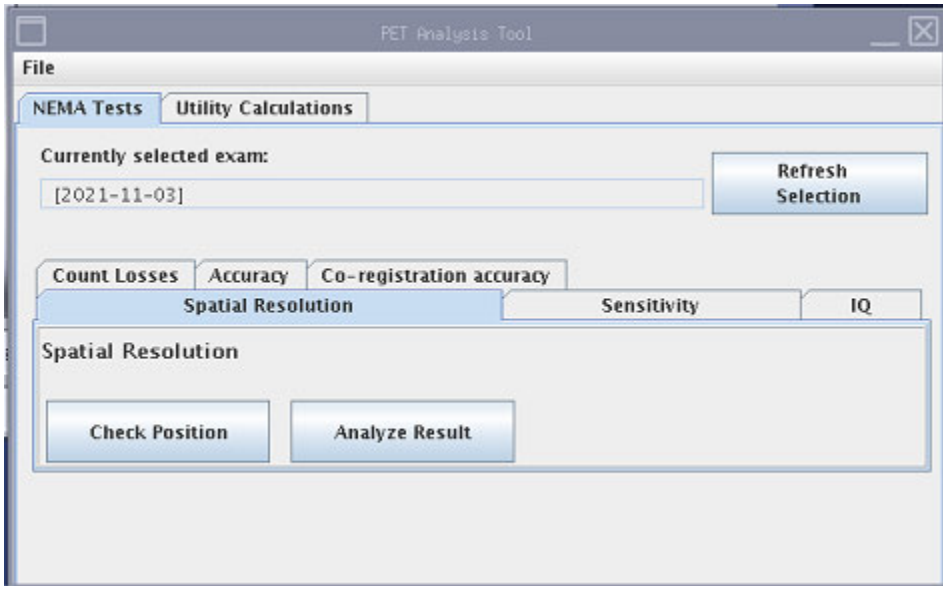


Figure 2.6: PET Analysis Tool - Spatial Resolution Tab Selected.

5. Refer to Figure 2.6. If necessary, click the SPATIAL RESOLUTION tab to display the CHECK POSITION and ANALYZE RESULT buttons.
6. Drag the Common Service Desktop screen out of the way to expose the service browser located directly beneath it.
7. Click/highlight the most recent Spatial Resolution image series in the service browser.
   - If necessary, check the scan times to make sure you select the most recent scan. If you add scans, rather than inserting them, the series order may change.
8. Refer to Figure 2.6. Click the CHECK POSITION button to prompt the system to analyze the point source position.
   - The button remains "depressed" until you close the panel

NOTE: Do NOT "double-click" any PET Analysis Tool buttons! The system takes several seconds to run the corresponding analysis and display the results. Although a button appears "depressed" until you close the corresponding results panel, all buttons continue to respond to clicks, and will continue to re-analyze the selected series until the system clears all the "clicks." You must close the current screen to initiate the next analysis in the queue. If you click a button multiple times, it may take several minutes to display and discard all the screens.

9. Refer to Figure 2.7. Review the contents of the table in the lower left corner of the right plot.
   - **The X-Y-Z values should fall between +/- 1.0 mm. For optimal resolution results, it is recommended to tune the position values down to +/-0.5 mm**.
10. If any value exceeds the +/- 1.0 mm range, turn the corresponding head holder knob(s) to reposition the point source holder in the SFOV and acquire the next 1-minute scan from the groups you duplicated in the previous section.
    • In Figure 2.7 (Left) example, point source #1, point source #2 and point source #3 are all inclined to the right when looked from the CT side of the gantry. The differences in X offsets of point source #1 and point source #3, and point source #2 and point source #3 are more than 1.0 mm. In Figure 2.7 (Right), the positions of point source #1 and point source #2 are inside acceptable range, while the position of point source #3 falls outside the acceptable range in the Z-axis direction. Refer to page 20 for instructions to correct such problems.

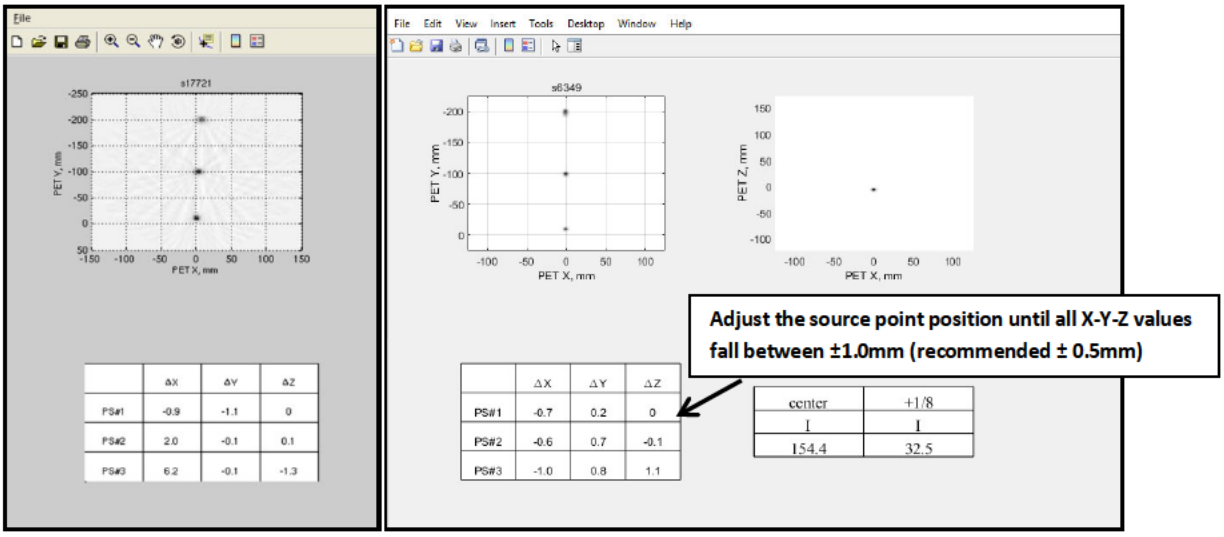
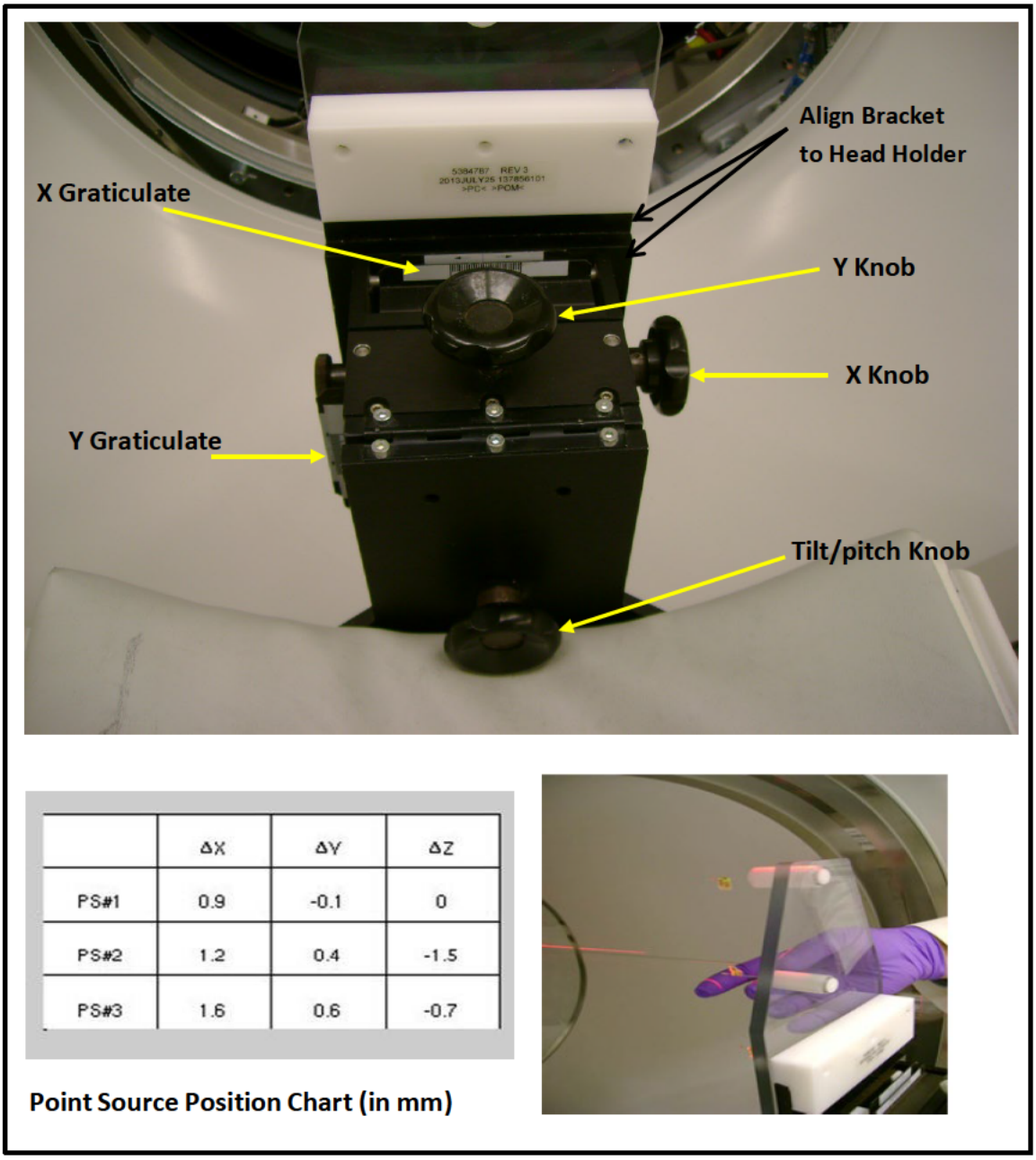


Figure 2.7: Check Position Results Panel with different misaligned examples (example for Omni Legend 32 cm axial FOV).

11. If one or more values fall outside the +/- 1.0 mm range, return to Section 2.2 and acquire another 1-minute scan, then return to this section to check the position.
12. You have the option to click FILE and print a hard copy of the screen or save the file.
    • Please go to the end of the next section for detailed instructions to print or save.
13. Click the upper left corner of the Check Position Results panel to display the menu.
14. Click or drag to CLOSE to close the Check Position Results panel and activate the buttons on the PET Analysis Tool panel.
15. When all X-Y-Z values fall within +/- 1.0 mm, proceed to Section 2.4.



	ΔX	ΔY	ΔZ
PS#1	0.9	-0.1	0
PS#2	1.2	0.4	-1.5
PS#3	1.6	0.6	-0.7

Point Source Position Chart (in mm)

Figure 2.8: Phantom Holder with Point Source Holder (Fixture 5384787-12).

Position Instructions

• **Points are inclined to the right (i.e. the X-offset values increase from lowest point (#1) to the top point (#3)):** If the absolute difference in X-offset between PS#1 and PS#2 is > 1.0 mm, and the absolute difference in X-offset between PS#2 and PS#3 is > 1.0 mm (example shown in Figure 2.7 **(left)),** slide a shim under the phantom on the left side looking from the back of the gantry. Note that this process may require few iterations until the respective differences between the sources come under +/- 1.0 mm.

• **Points are inclined to the left (i.e. the X-offset values decrease from lowest point (#1) to the top point (#3)):** If the absolute difference in X-offset between PS#1 and PS#2 is > 1.0 mm, and the absolute difference in X-offset between PS#2 and PS#3 is > 1.0 mm, slide a shim under the phantom on the right side looking from the back of the gantry. Note that this process may require few iterations until the respective differences between the sources come under +/- 1.0 mm.

• **X too negative**: Turn the X knob clockwise to shift the source holder to the right (~1.25 mm / turn).

• **X too positive:** Turn the X knob counterclockwise to shift the source holder to the left (~1.25 mm / turn).

• **Y too negative:** Turn the Y knob counterclockwise to lower the source holder (~1.25 mm / turn).

• **Y too positive:** Turn the Y knob clockwise to raise the source holder (~1.25 mm / turn).

• **PS#2 and/or PS#3 too negative in the Z direction:** Gently pull the PS#1 capillary tube away from the source holder by turning the white plug counterclockwise by the mm shown on the chart (1.5 mm/turn).

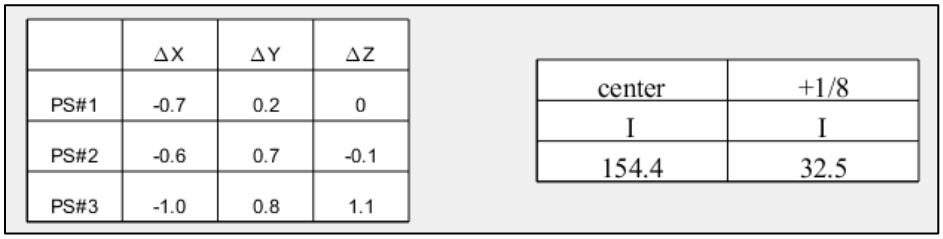
• **PS#2 and/or PS#3 too positive in the Z direction:** Gently pull the corresponding capillary tube(s) away from the source holder by turning the white plug counterclockwise by the mm shown on the chart (1.5 mm/turn). The objective is to move the activities of all three capillary tubes into the same scan plane.

2.4 Acquire and Analyze the Spatial Resolution Scans

Follow the instructions in Section 2.2 and 2.3 to align all the three point-sources to the same SFOV, +/- 1.0 mm. When all three sources fall within the +/- 1.0 mm range, follow the procedure in this section to acquire and analyze the Spatial Resolution scans.

NOTE: The object is to acquire an image with at least 500,000 counts. If necessary, use IMAGE WORKS to check the Total Prompts column to make sure you acquired at least 500,000 counts during each positioning scan. If you notice your Total Prompts fall below 500,000, increase the Spatial Resolution series scan times accordingly.

1. Refer to Figure 2.9. When the point source positions fall within +/-1.0 mm of the actual Scan Field of View (SFOV) you may acquire the two remaining scans in the original Spatial Resolution protocol, after you follow the instructions in this section to change the corresponding scan Start Locations.
2. If you inserted additional position check scan sets that you did not use, delete them now.
    - Click on an extra scan set and click DELETE SELECTED SCAN to remove it.
3. Display the final position check screen, and locate the Scan Start Location chart in the bottom right corner of the position check screen. It is recommended to save the image of the final position check screen.



	ΔX	ΔY	ΔZ
PS#1	-0.7	0.2	0
PS#2	-0.6	0.7	-0.1
PS#3	-1.0	0.8	1.1

center	+1/8
I	I
154.4	32.5

Figure 2.9: Point Source Position Chart and Scan Start Location Chart (example for Omni Legend 32 cm axial FOV).

4. For Omni Legend Series, refer to Figure 2.9. The Start Scan Location chart shows the PS#1 scan start location at the Center FOV and 1/8 FOV. Use these values as the actual Start Locations for the final two scans in the Spatial Resolution Protocol. In the Figure 2.9 example, the center FOV start location is I154.4 and the 1/8th FOV location is I32.5.
5. Enter an identifiable description into the Scan Description and Series Description data fields, such as "1_8 FOV" and “Center FOV”.
6. Replace the Start Location of the remaining “Center FOV” and “1_8 FOV” scans with the center and the +1/8 values, respectively, from the Scan Start Location Chart.
7. Click CONFIRM to acquire the first scan of the high-resolution set in the Spatial Resolution protocol.
8. If necessary, press the MOVE TO SCAN button when it flashes.
9. Press the START SCAN button when it flashes to initiate the data acquisition.
10. Click CONFIRM to acquire the second scan of the high-resolution set in the Spatial Resolution protocol.
11. If necessary, press the MOVE TO SCAN button when it flashes.
12. Press the START SCAN button when it flashes to initiate the data acquisition.

3.5, 3.6, 3.7, 3.8

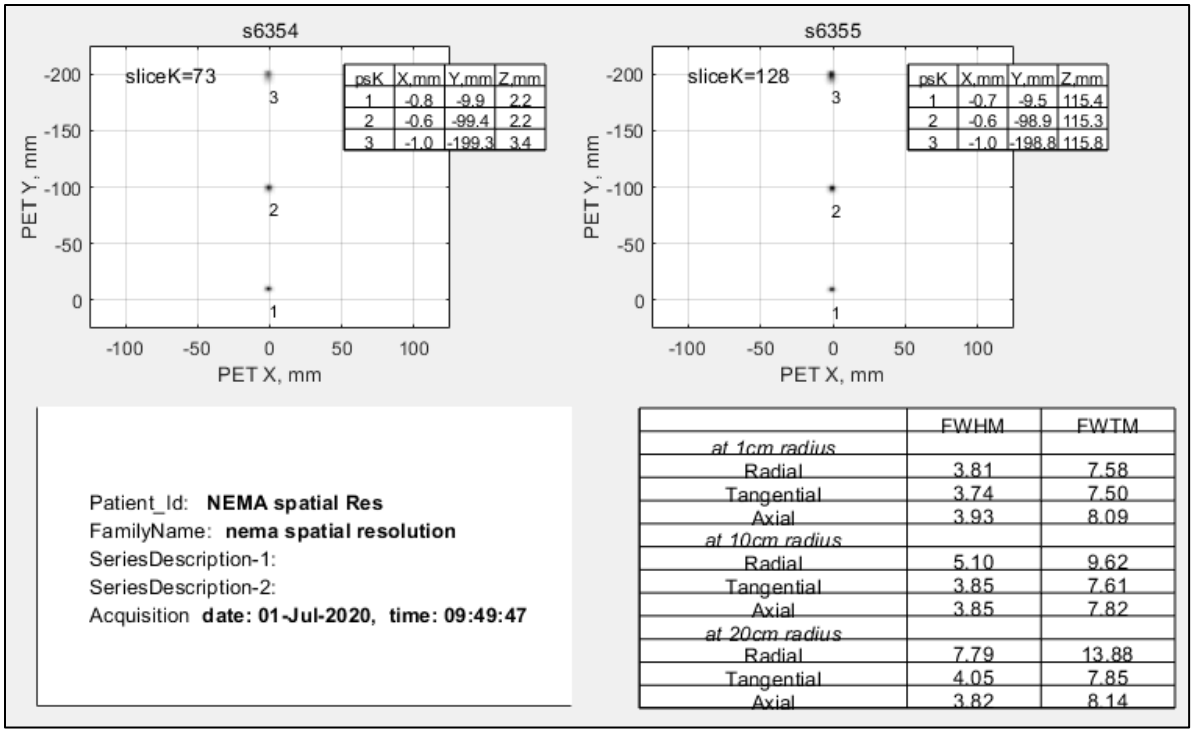
NOTE: If you would like to measure spatial resolution with Q.Clear reconstruction then CTAC series are needed for the attenuation correction. For the suitable CTAC series follow the procedure bellow:

a. Click CT to display the CT acquisition view/edit screen.
b. Use the protocol CT range and verify the CTAC series prescription contains the following parameters:
    • Patient Orientation: Head First (Landmark: SN)

- Scan Type: Helical, Full, 0.5 sec.
- Thick Speed: 3.75, 39.37, 0.984:1
- kV: 140 kV
- mA: 50
- Recon DFOV: 70 cm
- Recon Type: PET AC, wideView

c. Click CONFIRM to initiate the CTAC scan sequence.
d. If an error message “PET range is not covered by CT” is obtained elongate the CT range so it will cover two beds suitable for the attenuation correction of the center and 1/8 FOV PET scans and initiate the CTAC sequence.

13. Upon completion of the Spatial Resolution scan acquisitions, select the 1/8th FOV and Center FOV series from the Service browser.
14. Press and hold the SHIFT key while you click/highlight both series to select them.
15. If necessary, close any existing position check screen to activate the PET Analysis Tool buttons.
16. If you closed the PET Analysis Tool screen:
    a. Click the SERVICE icon to display Common Service Desktop (CSD).
    b. If necessary, click the PET radio button to display the PET CSD.
    c. Click the IMAGE QUALITY icon to open the corresponding tab.
    d. Click NEMA ANALYSIS TOOL to display the PET Analysis Tool panel, shown in Figure 2.6. If necessary, click the SPATIAL RESOLUTION tab.
17. With the 1/8th FOV and Center FOV series highlighted in the Service browser, click ANALYZE RESULT to display a screen presented in Figure 2.6.
    - Do NOT "double-click" the button! The system takes several seconds to analyze the point source positions and display the results. If you click multiple times, system will analyze the results multiple times, and display each subsequent results panel several seconds after you close the previous panel.



	FWHM	FWTM
at 1cm radius		
Radial	3.81	7.58
Tangential	3.74	7.50
Axial	3.93	8.09
at 10cm radius		
Radial	5.10	9.62
Tangential	3.85	7.61
Axial	3.85	7.82
at 20cm radius		
Radial	7.79	13.88
Tangential	4.05	7.85
Axial	3.82	8.14

Figure 2.10: Example of a Resolution Report Panel (obtained for Omni Legend 32 cm axial FOV).

18. To print the results:
    a.) Click FILE in the toolbar of the Resolution Report panel.
    b.) Click or drag to PRINT to send a copy of the screen to the designated local printer.
19. To save the results to a file:
    a.) Click or drag to SAVE AS to display a browser presented in Figure 2.11.
    b.) Select a destination folder.
    c.) Click the Files of Type bar and select a file type extension from the scrolling list.
    d.) Click SAVE to save the corresponding file type in the selected folder.
20. Compare the listed results to the values in Table 6 in Section 8.
    • The transverse spatial resolution is an average of the radial and tangential values.
    • If the value falls below the corresponding value in Table 6, the test passes.
21. Click the upper left corner of the Resolution Report panel to display the menu.
22. Click or drag to CLOSE to close the Resolution Report panel and activate the buttons on the PET Analysis Tool panel.
23. Click the upper left corner of the PET Analysis Tool panel to display the menu.
24. Click or drag to CLOSE to close the PET Analysis Tool panel.
25. Drag the Common Service Desktop back into view.
26. Click the upper left corner of the Common Service Desktop panel to display the menu.

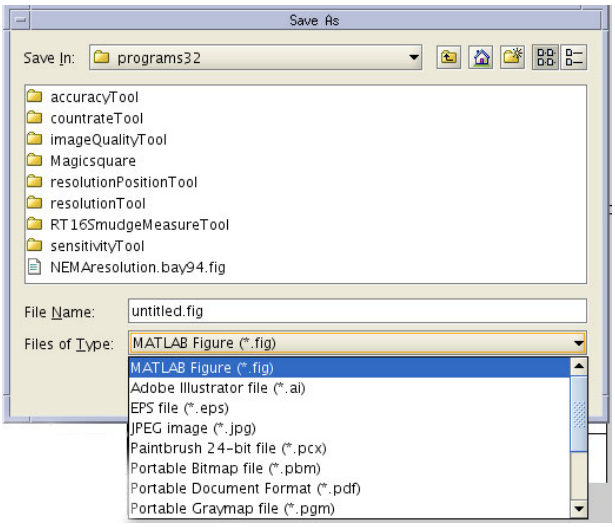


Figure 2.11: Save As Browser with Files of Type List Displayed.

27. Click or drag to CLOSE to close the Common Service Desktop.
28. Click END EXAM.
29. The system displays the message, "CT has not been scanned. Are you sure you want to end this exam?"
30. Click YES to close the message panel and end the exam.

Section 3. Sensitivity Test

The sensitivity test measures the number of counts (coincidence detection events) per second that the scanner makes for every unit of activity in the field of view. The test is run with activity levels so low, the count losses are negligible. The sensitivity measurements are made with differing amounts of attenuating material (Figure 3.2), with the results extrapolated to give the scanner sensitivity with no attenuating material. Randoms are subtracted from prompts to obtain trues only sensitivity results.

NOTE: The amount of activity at the time of the acquisition should fall between 1 MBq and 4 MBq. This level of activity is sufficient to produce measurable results while limiting deadtime losses to less than 5%. We recommend starting with a higher activity (e.g. 30 MBq) and waiting until the activity decays to below 4 MBq. Most dose calibrators have a larger error at lower activity and that is the reason to start with the higher activity and wait for the line to decay.

If you want to check the average block busy value, go to Image works, open Image header of raw data file series, find the path using ctrl+f "RDF". The path form is /petRDFS/.../SINO0000. Open Linux shell and write the following command:

rdfTeller -r -S /petRDFS/.../SINO0000 | grep "Block Busy Average Deadtime"

The average block busy value should be under 0.05, as demonstrated in Figure 3.1 below.

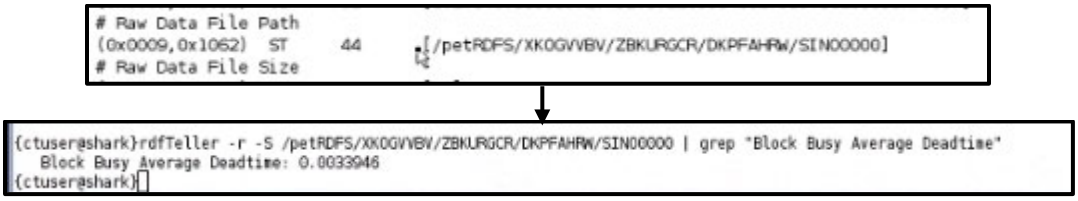


Figure 3.1: Viewing Block busy average deadtime for PET Image.

3.1 Prepare the Source

NOTE: If the site owns a sensitivity phantom, they may want to shorten the end of the 4 outer sleeves by a few mm. This practice maintain level by always supporting the central sleeve for all 5 measurements as shown in Figure 3.2

Figure 3.2: Trim 4 outer sleeves

19. A typical volume of the line source is 2.3 mL (70 cm long). The target is to create a solution of >2.3 mL at 8 MBq/cc (0.216 mCi/cc) i.e. total activity of at least between 15 to 30 MBq. One can follow the below steps directly, however, it is recommended that the tester consults Section 5.3 to use the formula given in step 7 with the appropriate activities required and explained for this test.
20. Draw 30 MBq (0.5 mCi) of F-18 into a syringe.
21. Empty the syringe into a clean container, and fill the container with water to 3 cc.
22. Use a new syringe to draw the diluted activity from the container.
23. Measure the syringe activity in a dose calibrator.

NOTE: The reported sensitivity is directly proportional to the dose calibrator readout. Be sure that the instrument calibration has been recently verified and the isotope is set to F-18. In addition, the clock in the dose calibrator and the scanner's clock should be synchronized to better than one minute.

24. Record the syringe activity measurement and the time of measurement.

25. Inject the syringe into a line until the central 70 cm of the line contains activity.
    - Fill only the central 70 cm of the line source, with F-18 from the syringe.
    - Cap or seal the ends of the line. (One end of the line source must be able to fit through the smallest diameter aluminum sleeve, refer to Figure 3.3 . You may use Critoseal to seal one end of the line if the smallest cap is too big to fit into the sleeve.)
    - Measure the length of the liquid inside the line. If the actual length is different from 70 cm then it should be considered in TRACER INFO, as described in step 9 in Section 3.2.
26. Return the syringe to the dose calibrator and record the post-injection time and activity. You will enter the pre- and post-injection times and activities into the Tracer screen.
27. Measure and mark the center of the smallest diameter aluminum sleeve with a permanent marker. The sleeve should be about 70 cm long; the center is at 35 cm.

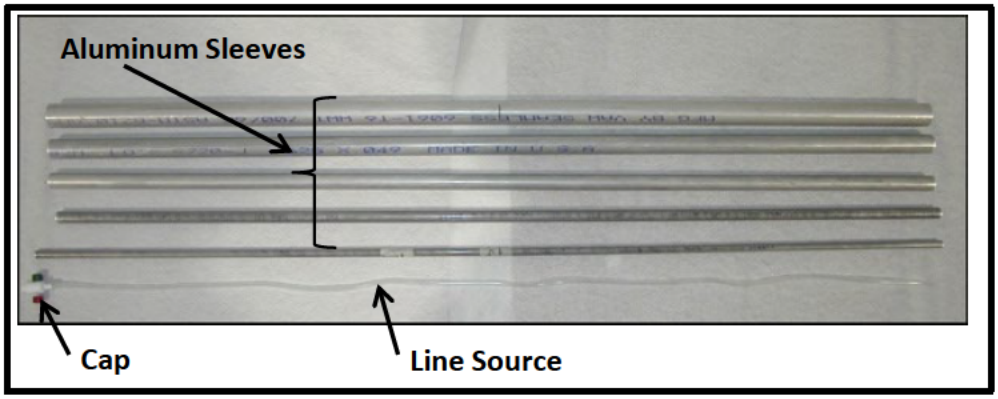


Figure 3.3: Line Source and Aluminum Sleeves.

28. Mount the source holder on the cradle, thread the line source through the smallest diameter aluminum sleeve and insert the sleeve into the holder, as presented in Figure 3.4.

3.2 Position the Source Line and Acquire the 3D Data

NOTE: It is important that while the line source is still at higher activity, meaning before it decays down to below 4 MBq, the CenterLineVectTool should be used to center the line in the scanner and make it ready for the actual test. Notice that aligning the line source using the patient's positioning lasers will align the source to the CT image space which is not necessarily aligned with the PET's FOV. Therefore, a PET-based alignment method is required (i.e. CenterLineVectTool). Image co-registration from PET to CT during clinical imaging is achieved through VQC calibration. Once the line source is prepared with 15 – 30 MBq, follow Steps 1 to 23 below to align the phantom using the default sensitivity protocol. Once the line source is centered, allow the activity to decrease to less than 4 MBq before scanning. The details of the execution of CenterLineVectTool are given below:

1. Move the Table base to the CT position.
2. Press the CT alignment light button to turn on the lasers.
    - Use the Sagittal and Coronal lasers to align the sleeve to isocenter and perpendicular to the scan plane. Refer to Figure 3.5.

- Option: the deviation between PET and CT centers can be reviewed by opening a sinogram acquired with the line source (described below – see Figure 3.7).

3. Note that the line source should be centered throughout all its length. Place a small bubble level on the holder to make sure that the holder is not inclined.

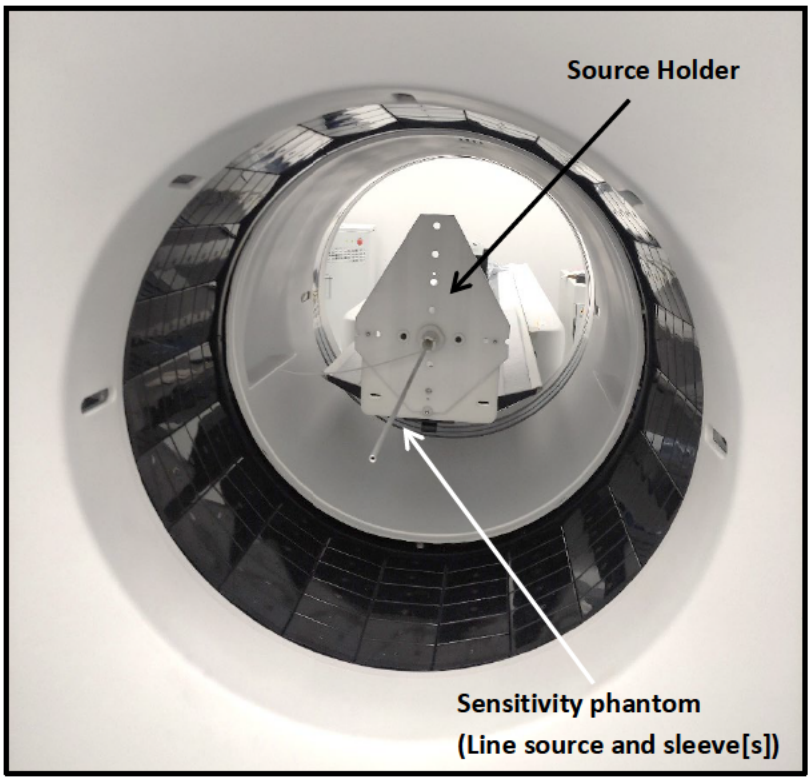


Figure 3.4: Measurement setup.

4. Align the axial laser line to the mark on the center of the aluminum sleeve. Refer to Figure 3.5.
5. Press the INTERNAL LANDMARK button to zero the gantry display.
6. Click NEW PATIENT to open the Patient Information screen.
7. Enter a Patient ID and Patient Name into the corresponding data fields to activate the Protocol Selection area. Use an easily identifiable name, such as NEMA Sensitivity.
8. Click ENTER PET TRACER INFO to open the panel shown in Figure 3.6.
9. Enter the activity in MBq or mCi for each of the Pre-Injection and Post-Injection Assay data fields.

To consider the possible variations in the length of the liquid-filled line the actual corrected activity should be calculated, according to NEMA NU 2-2018 requirements, using:

$$A_{cal} = A_{cal,meas}\frac{700}{L_{meas}}$$

where $A_{cal,meas}$ is the measured activity and L_{meas} is the measured source length in millimeters.

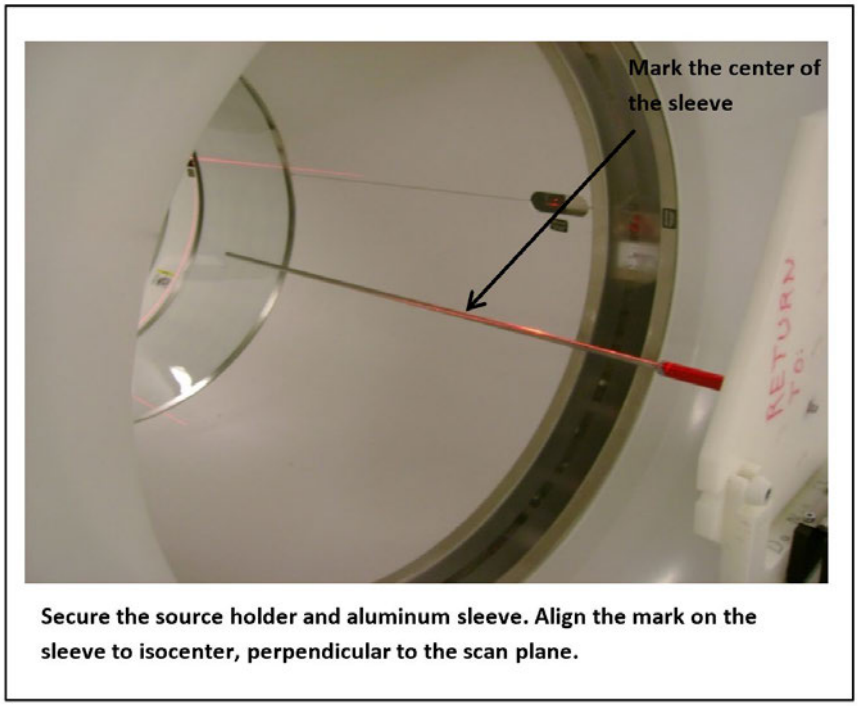


Figure 3.5: Position the Line Source in the center of the FOV

10. Enter the times and dates for both Pre- and Post-Injection assays.
    - The injection time MUST fall between the Pre and Post Injection times, even though this value will not be used in the calculation.
11. Click ACCEPT to close the panel.
12. If necessary, click the GE tab to select it.
13. Click beneath the Patient icon feet to display the Miscellaneous Protocol List.
14. Click the NEMA Sensitivity protocol description to open the View/Edit screen.
15. Click PET to display the PET acquisition view/edit screen with five scans. This NEMA test does not require a CT scan.
16. Modify the PET protocol by adding at least 3 series for positioning – PRESS insert series 3 times
17. Turn off Auto continue and Auto Run.
18. Acquire data for first series
    Click CONFIRM to initiate the first scan.
    Press the START SCAN button when it flashes to initiate the first scan.

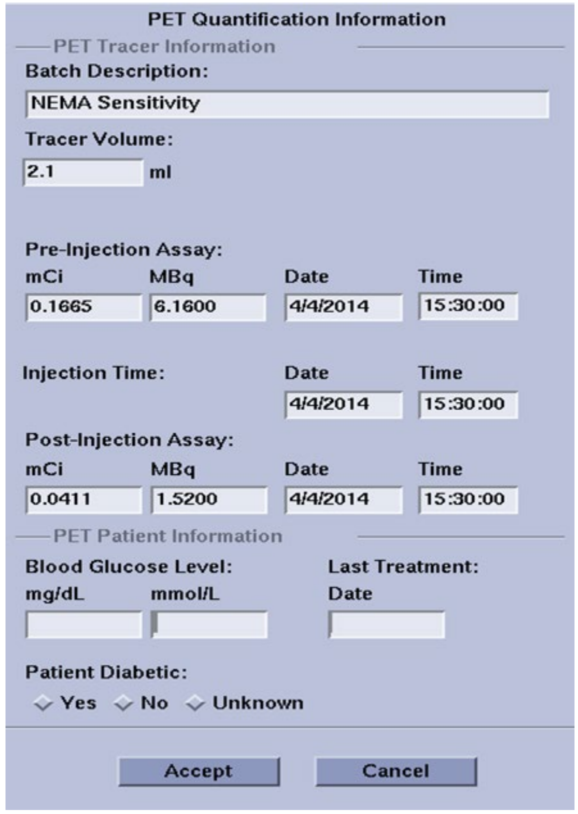


Figure 3.6: PET Tracer Information Panel.

19. Open a terminal window and execute the following command:
    CenterLineVectTool -i /petRDFS/MostRecentScan/SINO0000
20. Directions with adjustments to the position of the center line are displayed on the screen as shown in the following example:

```
<><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><<
<><><> MOVE PHANTOM AS FOLLOWS TO ALIGN IT TO CENTER AXIS OF THE SCANNER ...
<><><> Looking from the front of the gantry:
<><><> Raise this end of the phantom by 3.7 mm along the Vertical direction
<><><> Move this end of the phantom by 0.32 mm to the left along the horizontal direction
<><><> Looking from the back of the gantry:
<><><> Raise this end of the phantom by 3.3 mm along the Vertical direction
<><><> Move this end of the phantom by 0.77 mm to the left along the horizontal direction
<><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><<
```

21. Repeat steps 18 to 20, adjust position of the line until all adjustments suggested by the CenterLineVectTool are less or equal to 2 mm. Additional scans may be added as needed.

NOTE: In a case where the CenterLineVectTool is used on the line with the lower activity, the following error message might appear:

> **"Processing Centerline Vector for: /petRDFS/MostRecentScan/SINO0000; with Max Curve Fit iterations of 400. Cosine fit returned error as maximum number of iterations reached for slices: 1, 24, in RDF /petRDFS/MostRecentScan/SINO0000"**

If this occurs either increase the acquisition time of the positioning scan to obtain better data or use a source with higher activity.

22. A visual inspection of the line source alignment can be done using the sinogram from the last acquisition used for the source alignment.
    a. Open investigator (Investigator can be found under Service Desktop / PET radio button / Image Quality tab / Investigator)
    b. Select the Sensitivity exam and last series acquired (900 series)
    c. PRESS Show Sino icon on the right-hand side of the investigator dialog box (see Figure 3.7). Open a terminal window and use the window's edge to check that the line in the sinogram is straight.

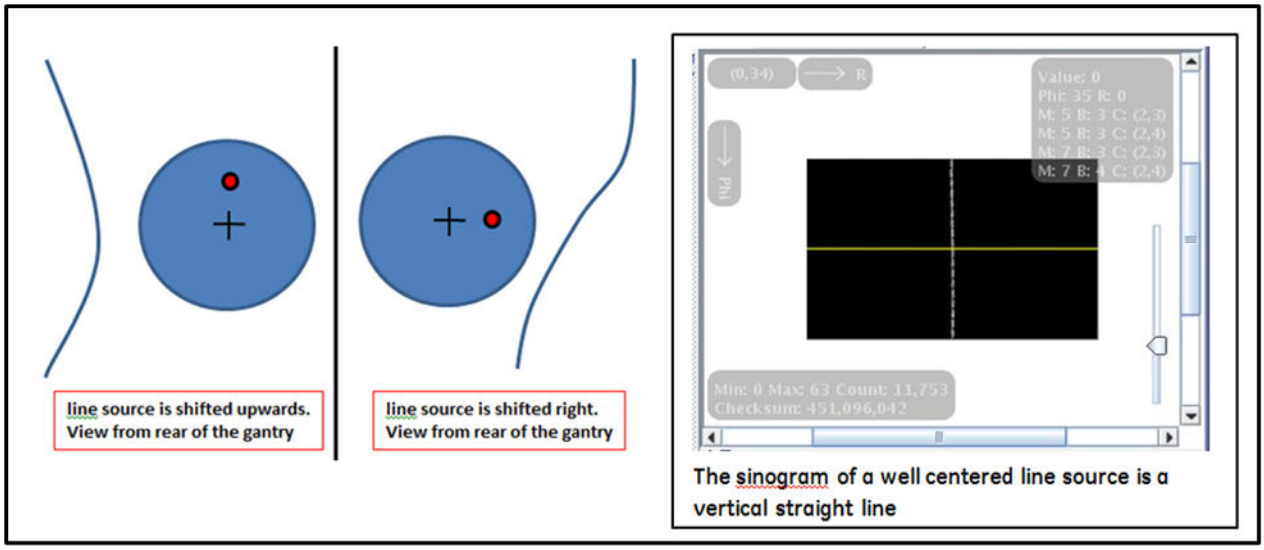


Figure 3.7: Sinogram of line source (improper alignment (left) and proper alignment (right).

23. Once ready with the centering of the line delete any additional series that were inserted and not used for line centering.
24. Make sure there are at least 5 remaining series in the exam for the Sensitivity acquisitions. Label these scans as "Frame 1 Center" through "Frame 5 Center". If in addition to measuring sensitivity at center, you intend to measure Sensitivity at 10 cm offset from the center of the FOV, add 5 additional series and label them "Frame 1 - 10cm" through "Frame 5 – 10 cm". Note, that if the 10 cm position is reached by table elevation, then for the 10 cm measurements a new and separate scan should be started. Auto Continue and Auto Run should be enabled.

25. Wait for activity in the line to decay to ~ 4 MBq or less.
26. Click CONFIRM to initiate the first scan.
27. Press the START SCAN button when it flashes to initiate the first scan.
28. Refer to Figure 3.8. Upon completion of the first scan, slide the next larger sized sleeve over the existing aluminum sleeve and line source.
    - Do NOT press the flashing START SCAN button until you add the next sleeve!
29. After each subsequent scan completes, slide the next larger sleeve over the existing line source and verify the sensitivity phantom is still leveled in the FOV, then press the flashing START SCAN button, until you complete all five scans. Each additional aluminum sleeve increases the attenuation. Make sure you do not dislodge the line source while sliding the next sleeve into place.
30. After completing five scans, remove the four outermost sleeves from the sensitivity phantom

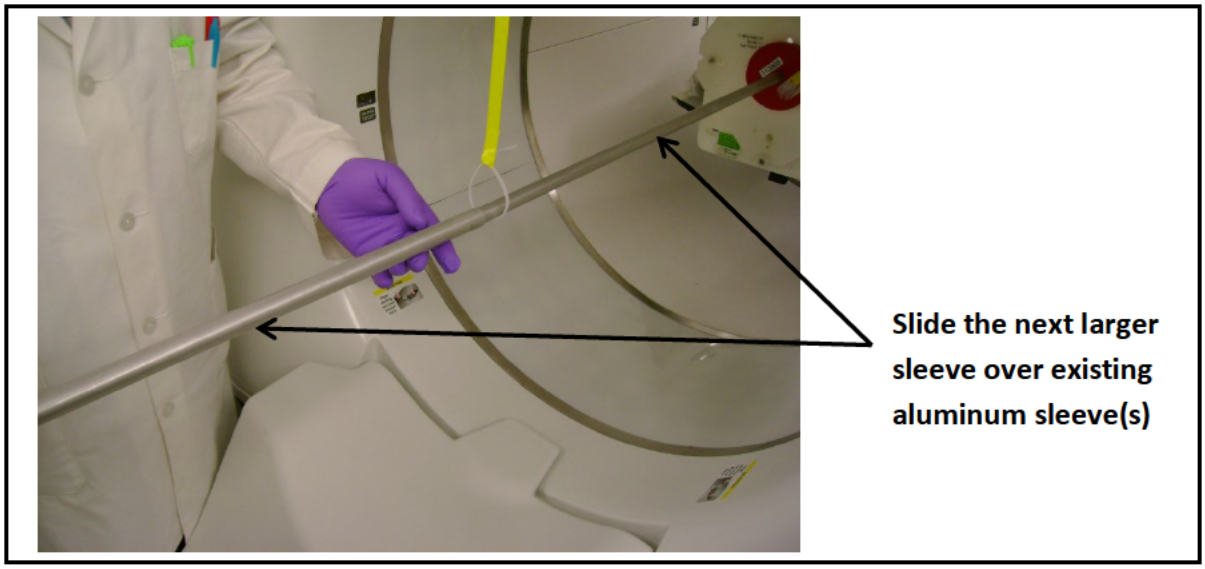


Figure 3.8: Add the Next Larger Diameter Aluminum Sleeve between Scans.

31. If you are also measuring Sensitivity at 10 cm move line source to the x=0 cm, y=-10 cm position on the source holder and continue to next step, otherwise Click END EXAM. Note, that if the y=-10 cm position is reached by table elevation, then a new and separate scan should be started for the measurements.
32. If you do not have five additional series for the 10 cm measurement, add them at this point (see step 24).
33. The system displays the message, "CT has not been scanned. Are you sure you want to end this exam?"
34. Click YES to close the message panel and end the exam.

In case the above exam has been terminated without acquiring the 10 cm position measurement, follow these steps:

1. Reestablish the landmark as described above. Move the line source to the x=0 cm, y=-10 cm position on the source holder.
2. Click NEW PATIENT to open the Patient Information screen.
3. Type/enter a Patient ID and Patient Name into the corresponding data fields to activate the Protocol Selection area. Use an easily identifiable name, such as NEMA SENSITIVITY Y10.
4. Click ENTER PET TRACER INFO to open the panel shown in Figure 3.6.
5. Enter the activity in MBq or mCi, corrected for length variation of the liquid-filling, for each of the Pre-Injection and Post-Injection Assay data fields.
6. Enter the times and dates for both Pre- and Post-Injection assays.
    - The injection time MUST fall between the Pre and Post Injection times, even though this value will not be used in the calculation.
7. Click ACCEPT to close the panel.
8. If necessary, click the GE tab to select it.
9. Click beneath the Patient icon feet to display the Miscellaneous Protocol List.
10. Click the NEMA Sensitivity protocol description to open the View/Edit screen.
11. Click PET to display the PET acquisition view/edit screen with five scans. This NEMA test does not require a CT scan.
12. Click CONFIRM to initiate the first scan. Check the level of the assembly with the line level before the start of the scan.
13. Press the START SCAN button when it flashes to initiate the first scan.
14. After each subsequent scan completes, slide the next larger sleeve over the existing line source and sleeves, verify the sensitivity phantom is still leveled in the FOV, then press the flashing START SCAN button, until you complete all five scans.
15. Click END EXAM.
16. The system displays the message, "CT has not been scanned. Are you sure you want to end this exam?"
17. Click YES to close the message panel and end the exam.
18. Upon completion of the second Sensitivity exam, proceed to Section 3.3.

3.3 Analyze the Data

Upon completion of the second Sensitivity exam, follow the instructions in this section to use the PET Analysis Tool to calculate the results.

1. Click SERVICE to display the Common Service Desktop.
2. If necessary, click the PET radio button.
3. Click IMAGE QUALITY to display the tab contents.
4. Click NEMA ANALYSIS TOOL to open the PET Analysis Tool panel.
5. Click the SENSITIVITY tab to display its button.
6. Drag the Common Service Desktop screen to the bottom of the monitor, to expose the Service browser, located directly beneath it.

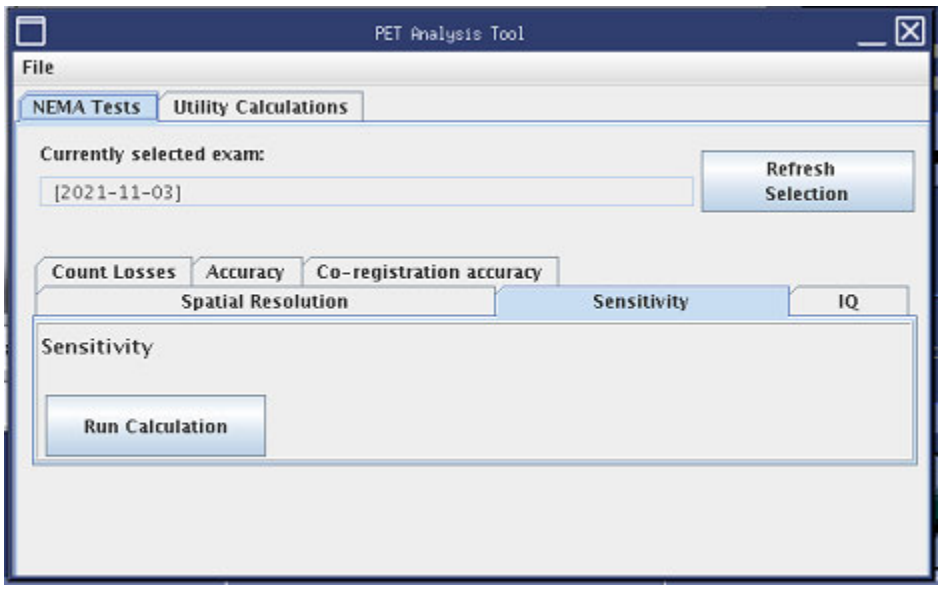


Figure 3.9: PET Analysis Tool - Sensitivity Tab Selected.

7. Click/highlight one of the Sensitivity exams to select it.
8. Select the five LIVE series to select them.
   - Click/highlight the first LIVE series, then press and hold the SHIFT key while you click on the last LIVE series to highlight/select all five LIVE series.
9. Refer to Figure 3.9. With all five series highlighted, click RUN CALCULATION.
   - Do NOT "double-click" the button! If you click multiple times, system runs a calculation for each "click." You must close the currently displayed panel to proceed to the next calculation in the "click" queue.
10. After several seconds of calculation, the system displays a Sensitivity Report screen similar to the one shown in Figure 3.10.
11. Compare the results to the Sensitivity value listed in Table 8 in Section 8.
    - If the Sensitivity value for your system is higher than the value listed in the table, the system passes the test.
12. Repeat Step 7 through Step 11 to process the sensitivity data for the second measurement.
13. To print the results:
    a. Click FILE in the toolbar of the Sensitivity Report panel.
    b. Click or drag to PRINT to send a copy of the screen to the designated local printer.
14. To save the results to a file:
    a. Click or drag to SAVE AS to display a browser similar to the one in Figure 2.11.
    b. Select a destination folder.
    c. Click the Files of Type bar and select a file type extension from the scrolling list.
    d. Click SAVE to save the corresponding file type in the selected folder.
15. Click the upper left corner of the Sensitivity Report panel to display the menu.
16. Click or drag to CLOSE to close the Sensitivity Report panel and activate the button on the PET Analysis Tool panel.
17. Click the upper left corner of the PET Analysis Tool panel to display the menu.

18. Click or drag to CLOSE to close the PET Analysis Tool panel.
19. Drag the Common Service Desktop back into view.
20. Click the upper left corner of the Common Service Desktop panel to display the menu.
21. Click or drag to CLOSE to close the Common Service Desktop.

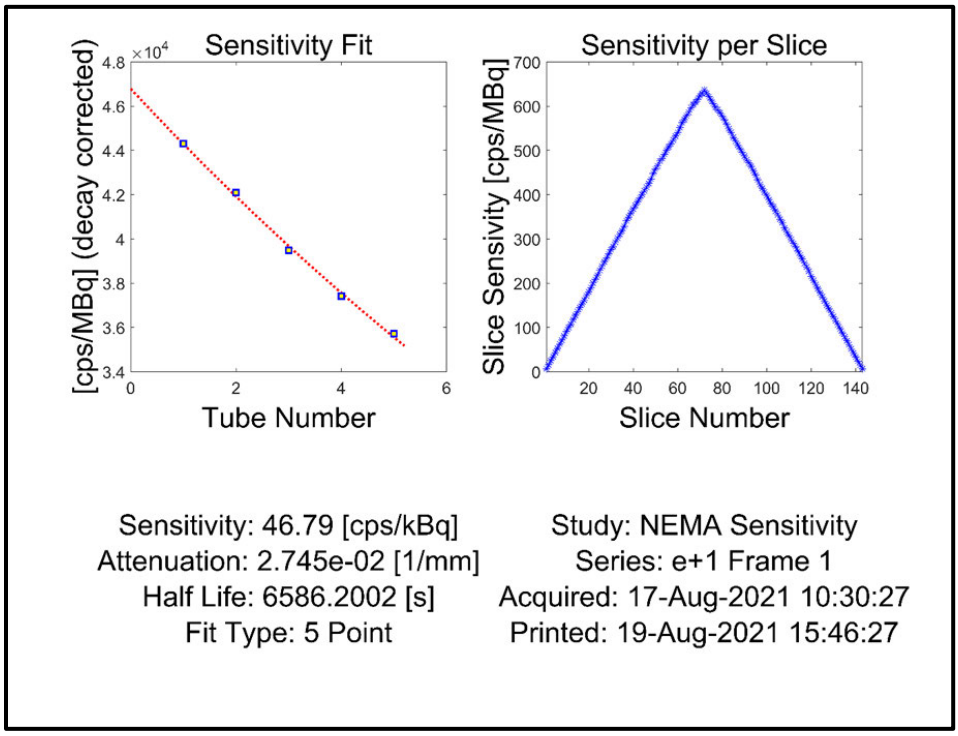


Figure 3.10: Sensitivity Report Screen (example for Omni Legend 32 cm axial FOV).

Section 4. Image Quality, Attenuation Accuracy & Scatter Correction Test

The image quality test simulates a PET-CT whole body clinical use case. Refer to Figure 4.1. The test phantom presents different sized hot spheres in a volume of non- uniform attenuation. Additional activity is placed outside the scan FOV, to represent scatter radiation, refer to Figure 4.2. Image quality is reported in terms of image contrast and signal-noise ratios for the hot spheres.

4.1 Phantoms

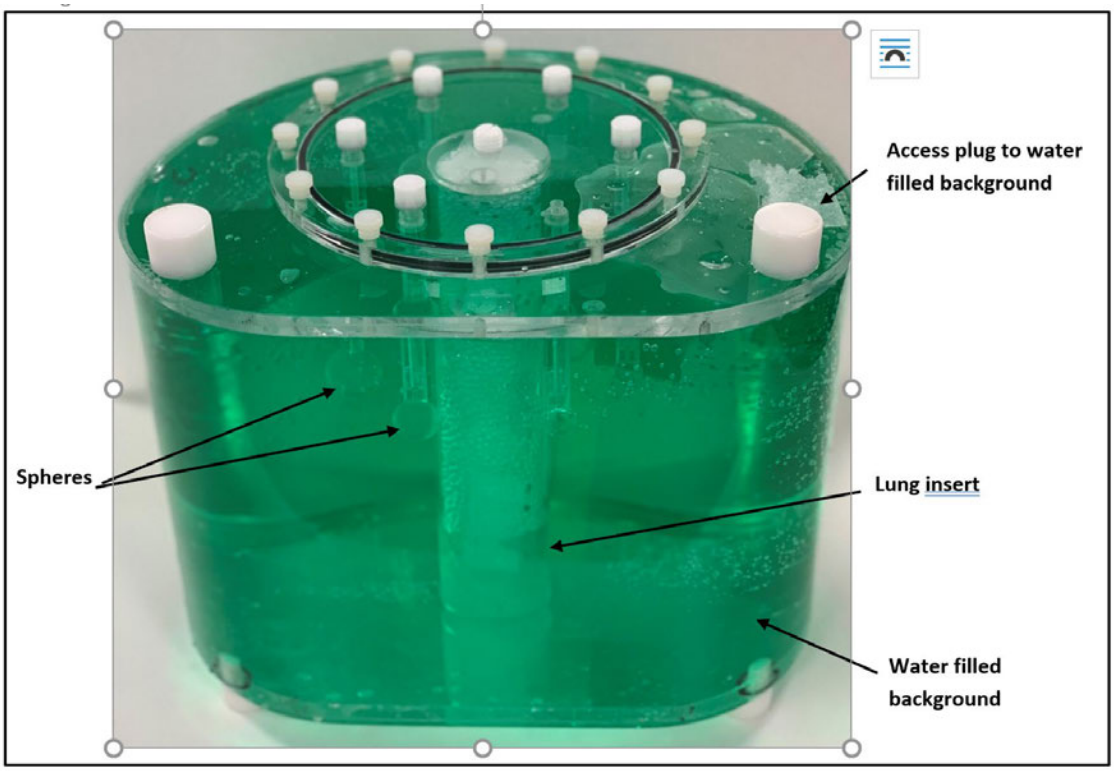


Figure 4.1: Example of an Image Quality Phantom – change for NEMA 2018.

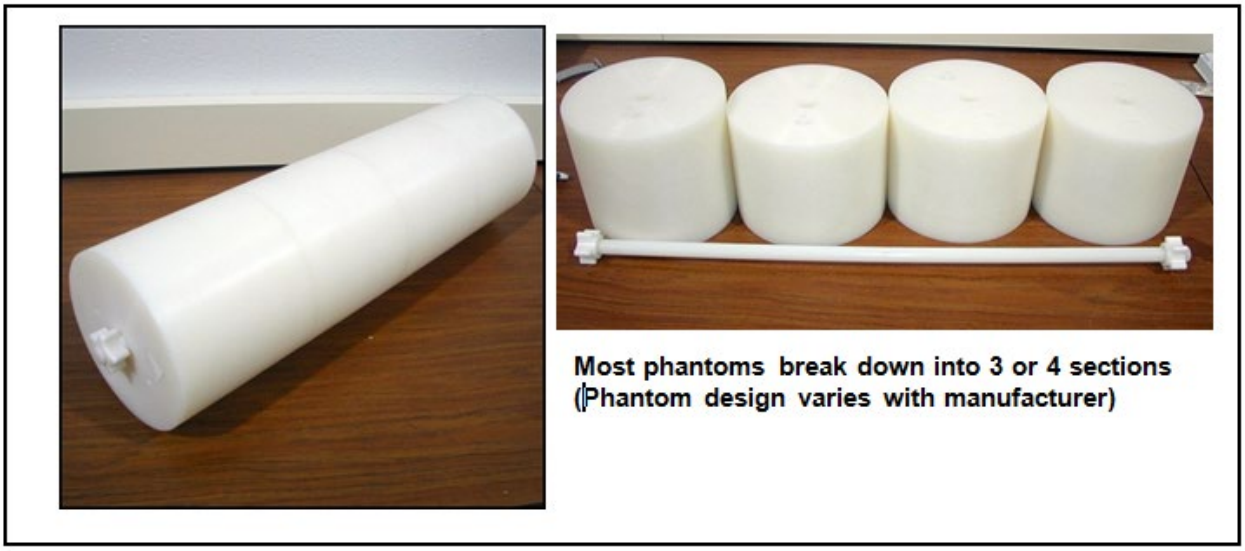


Figure 4.2: Example of a NEMA Scatter Phantom.

4.2 Calculate the Activity

This test uses an Image Quality phantom and a line source. Follow the procedures in this section to calculate the activity levels you need to fill the phantom and the line source. The NEMA NU2 standard recommends multiple measurements to improve the reliability of the results. The durations of the subsequent replicate scans should be adjusted for physical decay in order to acquire the same number of decays.

NOTE: The filling method described will deliver a 4:1 concentration ratio between the hot spheres and the background volume. This method does not require the calculation of specific volumes to determine activity concentrations.

You may use alternate methods to calculate concentrations for known phantom volumes. The alternate method allows you to prepare a separate volume of solution concentrate for the hot spheres.

1. Refer to Figure 4.1 and Table 3. The typical background volume equals the volume of the phantom minus the volumes of the lung insert and sphere assembly. A typical background volume is 9792 cc. Total volume of all filled spheres is approximately 60 cc.
2. Determine the amount of time you think it will take to fill and position the phantom. A typical time is 60 minutes. Calculate higher activities at the time of fill so they can decay to the correct activities by time of scan.
3. Use the estimated fill time to determine the amount of activity you must inject in order to attain the 21 kBq/cc (0.6 uCi/cc) and 5.3 kBq/cc (0.15 uCi/cc) activity levels at scan time in the hot spheres and the IQ phantom background, respectively.
4. Measure out about 80 cm of plastic tubing to use as the scatter fraction line source.
    - Determine the volume of the central 70 cm of tubing. A typical value is 5 cc.
5. Refer to Figure 4.3. Verify that the tubing can be threaded through the NEMA scatter fraction

phantom before you fill the tubing with activity.

6. Prepare a volume of solution to fill the central 70 cm of the scatter fraction source.
    - Aim for an activity of 120 MBq (3 mCi) at scan time.

Table 3: Source Activities at the time of Scan

Phantom Volume	Typical Volume	Activity	Activity Concentration
Background	9792 cc	52MBq (1.4 mCi)	5.3 kBq/cc (0.14
Hot spheres	~60 cc	N.A.	21.2 kBq/cc (0.57 uCi/cc)
Lung Insert	0.3±0.1g/cc	0	0
Line	5.15 cc	120 MBq (3.24	N.A.

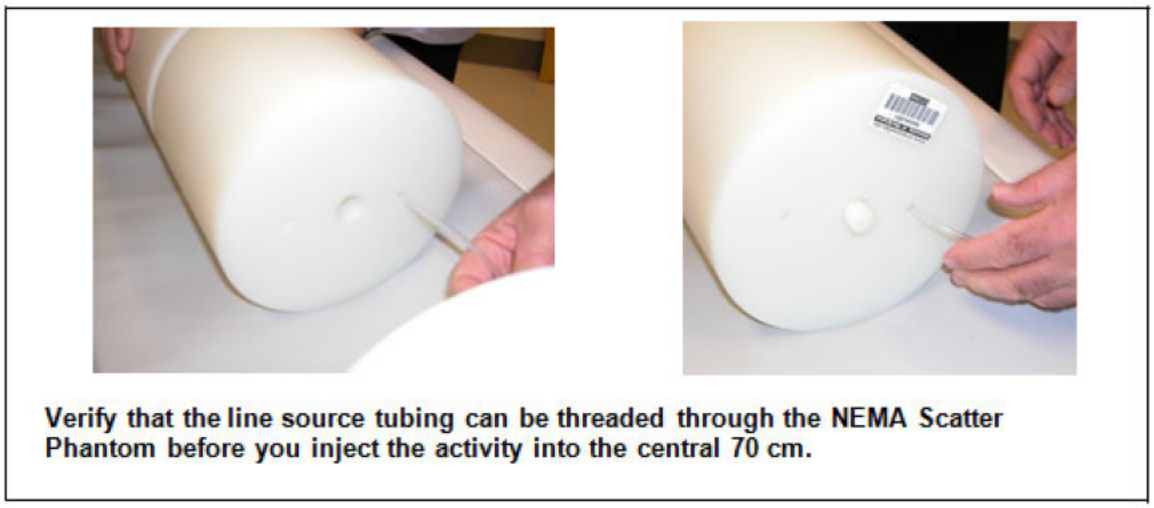


Figure 4.3: Thread the Line Source Tubing through the NEMA Phantom.

4.3 Fill the Line Source

Use the Table 3 values during this procedure.

1. Draw an amount of F-18 activity equal to the calculated injection activity into a syringe.
2. Refer to Table 3 and Figure 4.4.
    a. Flush the contents of the syringe into a container.
    b. Add dye, such as food coloring (optional).
    c. Add water to the container until the total volume equals the solution volume in Table 3.

Figure 4.4: Prepare the Line Source Activity

3. Use a new syringe to draw the activity from the container.
4. Fill the central 70 cm of the scatter fraction line source from the syringe.
5. Plug both ends of the tube using Critoseal (clay from Cha-Seal catalog No 510, Tube Sealing Compound).

4.4 Fill the Image Quality Phantom Volumes

1. Before start of the fill, please weight the phantom volume, a typical value is ~9.8 kg.
2. make sure that the smallest sphere in the phantom is in the 1 o'clock position, and the other spheres go in increasing size counter-clockwise when looking at the top of the phantom (Figure 4.5). If not, remove the screws holding the top flange and rotate/rearrange the spheres starting at the 1 o'clock position.
3. Refer to Figure 4.1. Fill the Image Quality phantom lung insert with lung simulating material with an average density of 0.3 g/cc.
4. Refer to Figure 4.6. Fill the background volume of the Image Quality phantom one quarter of the way (25%) +50cc , namely 2500cc, with deionized water and some dye into the background volume of the Image Quality phantom. It is recommended to add enough dye for easier recognition of the solution surface inside the sphere capillary.
5. Add the activity to the background volume.
    a. Draw the calculated amount of F-18 Background activity into a syringe.
    b. Measure the syringe activity with the dose calibrator.
    c. Record the activity and time of the pre-injection and the post-injection activity of the syringe.
    d. Inject the contents of the syringe into the large volume (background) portion of the image quality phantom.

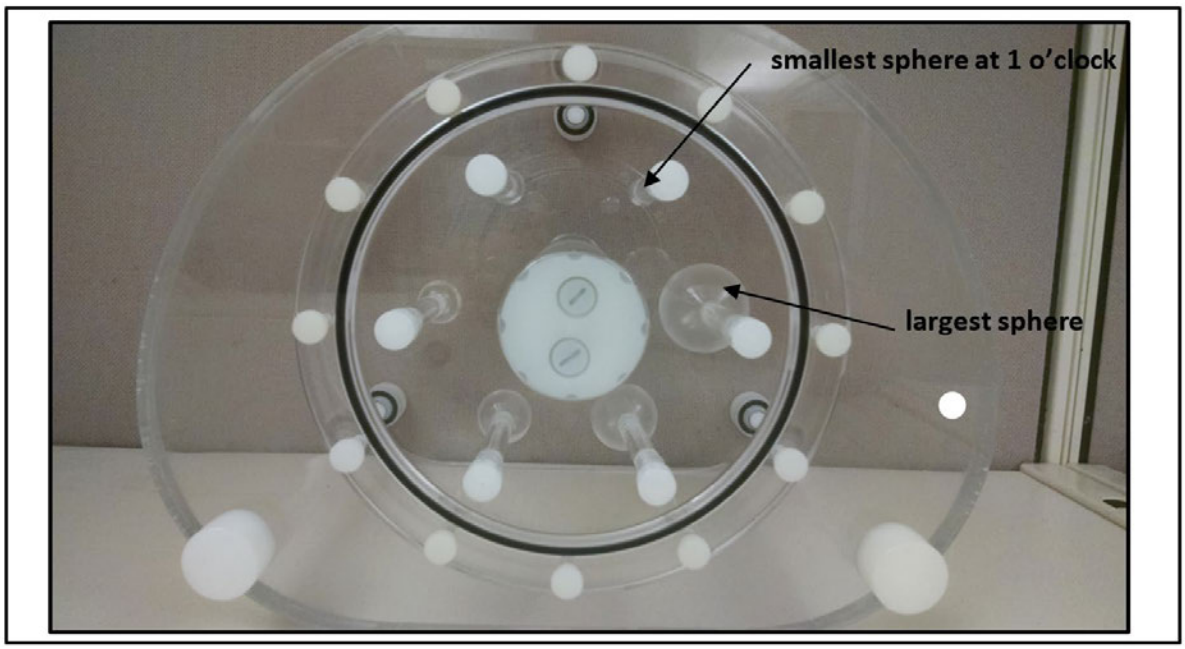


Figure 4.5 NEMA-IQ phantom top view. Positioning of spheres in phantom

6. Thoroughly mix the Image Quality phantom contents.
7. Fill a new syringe with the concentrated activity from the background volume.
   - Use a long needle (or narrow syringe) to reach the background volume and fill the syringe.
8. Refer to Figure 4.6. Fill all 6 spheres with the concentrated solution from the syringe. Pull the needle slowly out of the sphere as you fill it, to prevent the formation of air bubbles in the spheres. Refer to Figure 4.5 while fastening the spheres back on the lid of the IQ phantom.

NOTE: Good results depend upon the presence of valid activity concentrations in the hot spheres. When you fill the spheres, flush the solution in and out of the syringe a few times to assure each fill is at full concentration.

9. Empty any remaining solution in the syringe back into the background volume.
10. Fill the background volume with DI water until nearly full.
11. Mix well.
12. Top off the Image Quality phantom with DI water and eliminate all air bubbles.
13. Fasten all the fill plugs into place.

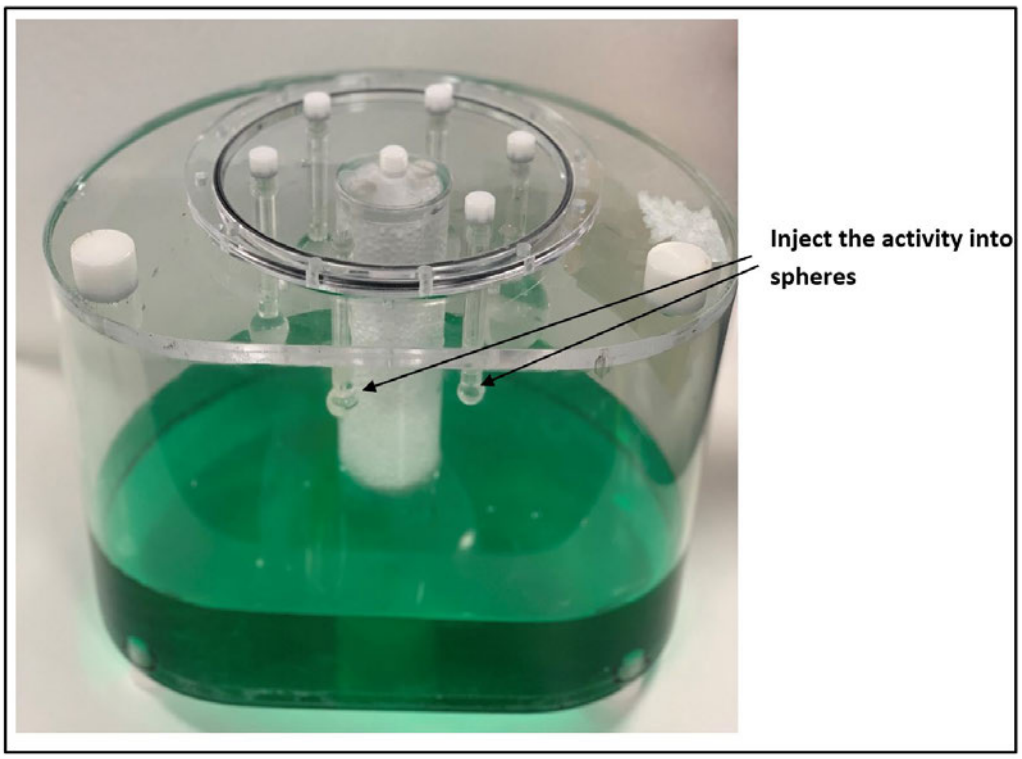


Figure 4.6: Fill the Spheres with Activity

4.5 Position the Source and Acquire the Data

Follow the procedure in this section to position the phantoms and acquire the data. During this procedure, you will select the NEMA Image Quality protocol from the GE protocol tab to prescribe a CTAC scan, followed by a PET scan for the prescribed time as listed in the procedure.

1. Refer to Figure 4.7. Position the Image Quality phantom on the cradle and orient it so the spheres are next to the scatter phantom. Position the front edge of the phantom back 15-20 cm from the front edge of the table.
2. Place the scatter phantom (with line source) just behind the Image Quality phantom out of the PET FOV.
3. Move the table base to the CT position.
4. Center the phantoms in the sagittal and coronal planes.
    a. Align the axial landmark line on the center of the spheres. The typical distance from the center of the spheres to the top surface of the phantom is 81.3 mm.
    b. Press the INTERNAL LANDMARK button to zero the gantry display.

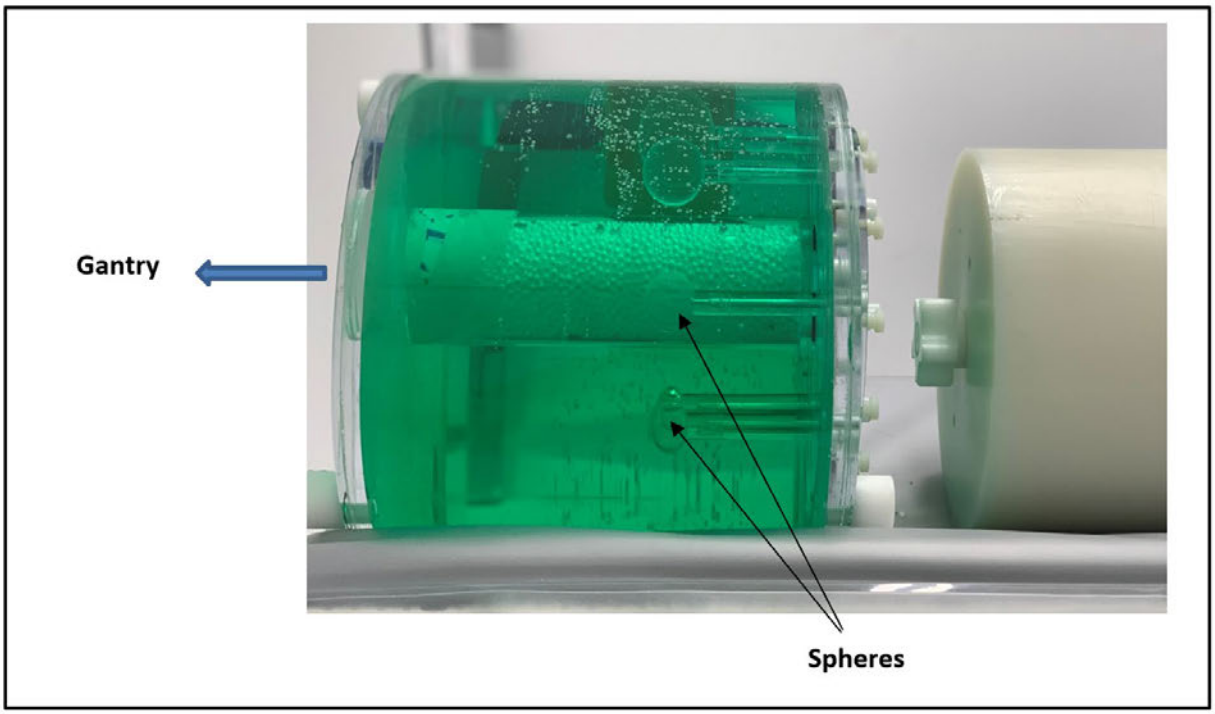


Figure 4.7: Image Quality Phantom Orientation.

1. Click the EXAM RX icon to open the PET-CT acquisition screen.
2. Click NEW PATIENT and fill in the following data fields:
   - Patient ID: NEMA IQ
   - Patient Name: NEMA IQ
   - Operator: your initials
3. Click the GE tab above the patient illustration to access the corresponding protocols.
4. Click beneath the illustrated patient's feet to display a list of protocol selections.
5. Select the NEMA Image Quality protocol to open the corresponding view/edit screen.

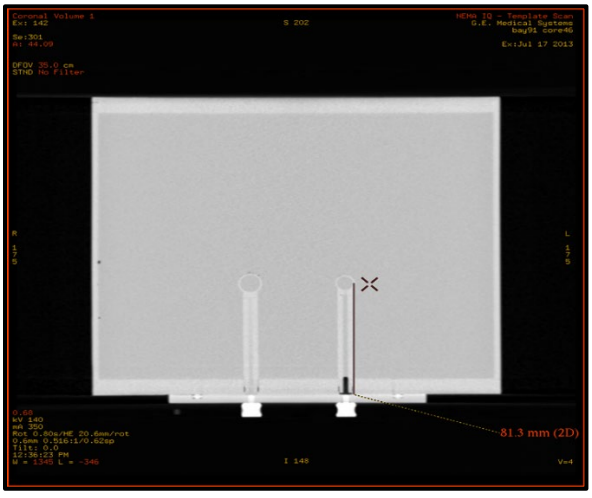


Figure 4.8: Coronal view of the NEMA IQ phantom.

6. Click CONFIRM to initialize the scout image acquisition sequence.
7. Upon completion of the first scout acquisition, click NEXT SCAN.
8. Use the Localizer (Graphic Rx) to position the centering cross directly over the smallest sphere in the torso phantom. Also make sure the line source of the scatter phantom is not visible in the PET scanning FOV.
9. Verify the CTAC series prescription contains the following parameters:
    - Patient Orientation: Head First (Landmark: SN)
    - Scan Type: Helical, Full, 0.5 sec.
    - Thick Speed: 3.75, 39.37, 0.984:1
    - kV: 140 kV
    - mA: Auto (under software control)
    - Recon DFOV: 70 cm
    - Recon Type: PET AC, wideView
10. Click CONFIRM to initiate the CTAC scan sequence.
11. Upon the completion of the CTAC scan, click PET to open the acquisition screen.
12. Type/enter a unique Scan Description and Series Description, such as IQ VPHD to identify the image file for later selection.
13. Verify the PET prescription screen contains the following parameters.
    - Scan Type: Static, ViP off
    - Scan Direction: Toward Head
    - Scan Time **(First scan):**
      00:07:05 (7 minutes, 5 seconds) for Omni Legend (32cm Axial FOV)
      00:03:29 (3 minutes, 29 seconds) for Omni Legend (16 cm Axial FOV)

    - Scan Time **(Second scan):**
      00:07:24 (7 minutes, 24 seconds) for Omni Legend (32 cm Axial FOV)
      00:03:33 (3 minutes, 33 seconds) for Omni Legend (16 cm Axial FOV)

    - Scan Time **(Third scan):**
      00:07:45 (7 minutes, 45 seconds) for Omni Legend (32 cm Axial FOV)
      00:03:38 (3 minutes, 38 seconds) for Omni Legend (16 cm Axial FOV)

14. Click on the symbol of the syringe to open the tracer parameters screen.
    - Click DOSE to display the entry fields.
    - Enter F18 into the Batch Description data field.
    - Enter the tracer volume: (9792 is a typical value)
    - In the patient weight field enter the phantom weight.
    - Enter the pre-injection and post-injection activities and times into the corresponding data fields. (Use the pre-injection date/time to fill the administration date/time data fields.)
    - Click OK to complete data entry and close the screen.
15. Click on the RECON Tab and verify the screen has the following parameters:

Table 4: Reconstruction Parameters

RECON Parameters	Omni Legend (32 cm Axial FOV) Omni Legend (16 cm Axial FOV)
Image Size	384 x 384
Recon Method	VPHD
Attenuation Type	MAC
Recon FOV	40 cm
Iterations	6
subsets	22
Filter cutoff	2
z-filter	None

16. Click OK to accept the settings and close the screen. Note that you need to start the scan only when you reach concentration of 5.3 kBq/cc.
17. Click CONFIRM to initiate the first of three PET scans.
18. Continue to execute the other two acquisitions in the protocol. The results from the three scans will be averaged later on.
19. Click END EXAM after the third acquisition completes.

4.6 Determine the Actual Sphere/Background Contrast

The instructions for filling the phantoms will result in the 4:1 concentration ratio between the background volume and hot spheres.

- If you used alternative methods to fill the volumes, calculate the exact ratio of concentrations.
- If you are using a concentration other than 4:1, enter that value into the Contrast Ratio field in Figure 4.9, below.

4.7 Analyze the Image Quality Data

Follow the instructions in this section to use the PET Analysis Tool to calculate the results.

1. Click SERVICE to display the Common Service Desktop.
2. If necessary, click the PET radio button.
3. Click IMAGE QUALITY to display the tab contents.
4. Click NEMA ANALYSIS TOOL to open the PET Analysis Tool panel.
5. Click the IQ tab to display its data field and button.
6. Type the exact ratio of concentration into the Contrast Ratio (adjusted to x:1) data field.
7. Drag the Common Service Desktop screen to the bottom of the monitor, to expose the Service browser located directly beneath it.
8. Click/highlight the NEMA IQ exam from the first acquisition to select it.
9. Click on the IQ image series to select it.
10. Refer to Figure 4.10. The REFRESH SELECTION button updates the data field display to the

currently selected Service browser exam. The system runs the calculation on the exam you selected in the Service browser, no matter what the data field displays.

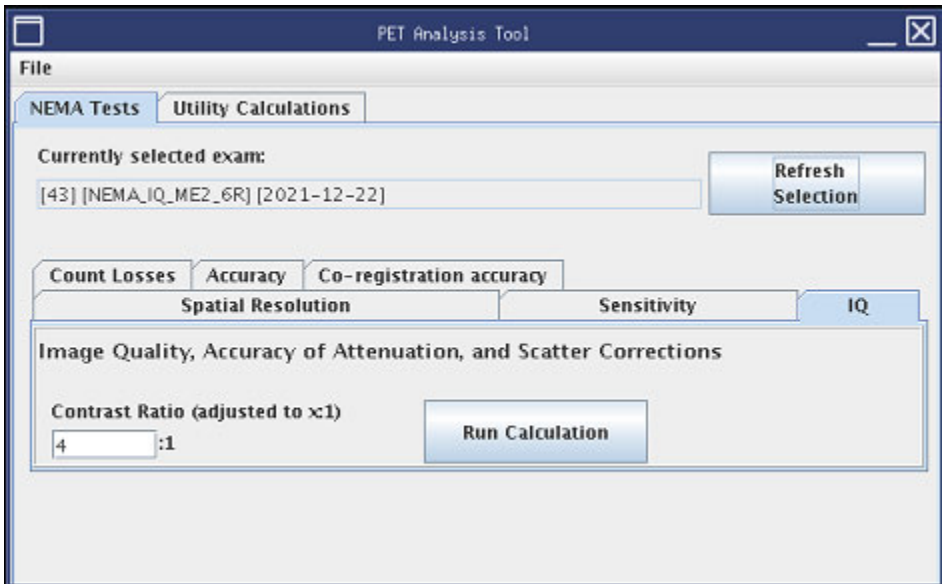


Figure 4.9: PET Analysis Tool - IQ Tab Selected

11. Refer to Figure 4.9. Click RUN CALCULATION.
    - After several minutes, the system displays a screen similar to Figure 4.10. Actual display may vary depending on the type of scanner.

NOTE: If the information on the IQ screen appears crowded and jumbled, click and drag one of the panel corners to enlarge the screen.

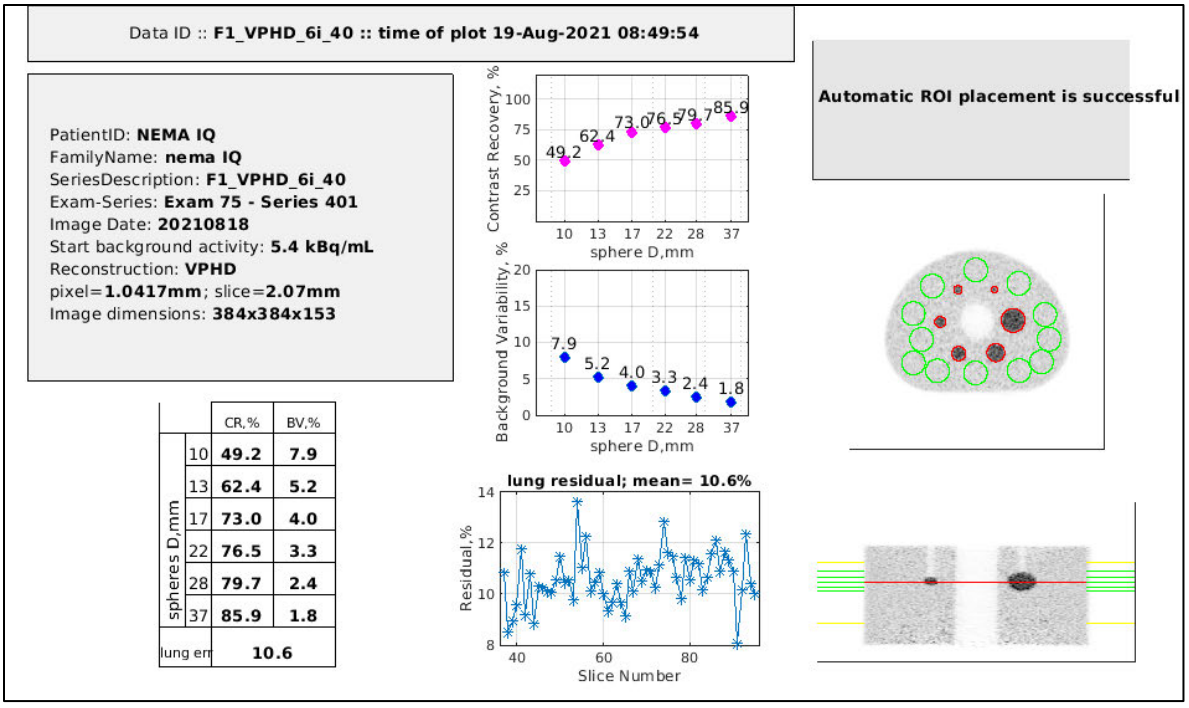


Figure 4.10: Example of an Image Quality Report Panel obtained in Omni Legend (32 cm axial FOV).

NOTE: This contrast measurement is subject to substantial variation, due to sphere filling, slice alignment, ROI placement and image statistics. The NEMA NU2-2018 standard recommends multiple measurements to minimize variation in observations.

12. Repeat steps 8 through 11 on the images produced from the other two acquisitions. Record the results in Table 5, and calculate average values as indicated in the same table.

NOTE: An option is provided to run the NEMA IQ analysis tool in a manual mode where one can manually place the ROIs on the spheres. This may be useful if the tool shows superposition of Background ROI with source spheres. Below are the details to use the manual mode if needed:

- Open terminal window and move to ***usr/g/service/matlab/programs.***
- Type command of ***run_imagequalitytool2018 ui*** to obtain a calculation where manual mode is certain to be offered. Make sure that the proper image series is selected in the image browser.
- When the tool comes up, select manual mode to allow user positioning of ROI's. Use the tool to move one or more sphere locations to optimal position as needed.

13. Compare the average values of Table 5 to the values listed in Table 12, Table 13, and Table 14 in Section 8 for the specific detector configuration.
14. To print the results:
    - Click FILE in the toolbar of the Image Quality Report panel.
    - Click or drag to PRINT to send a copy of the screen to the designated local printer.

15. To save the results to a file:
    - Click or drag to SAVE AS to display a browser similar to the one in Figure 2.11.
    - Select a destination folder.
    - Click the Files of Type bar and select a file type extension from the scrolling list.
    - Click SAVE to save the corresponding file type in the selected folder.

NOTE: the summary of all the processed IQ reports can be found in the ***usr/g/service/state/*** directory in the **pet_mfg.NEMA.log** file that can be opened using **gedit** or **kwrite** commands. Refer to section 1.1.

16. Click the upper left corner of the Image Quality Report panel to display the menu.

Table 5: Recovery Coefficients and Background variability results from 3 scans of the IQ phantom

	Hot Spheres						**Lung Error**
Diameter	10 mm	13 mm	17 mm	22 mm	28 mm	37 mm	50 mm
Measured Contrast % Acquisition #1							
Measured Contrast % Acquisition #2							
Measured Contrast % Acquisition #3							
Contrast % – average of above 3 measurements (write numbers in Tables in Section 8)							
Measured Background Acquisition #1							
Measured Background Acquisition #2							
Measured Background Acquisition #3							
Background – average of above 3 measurements (write numbers in Tables in Section 8)							

17. Click or drag to CLOSE to close the Image Quality Report panel and activate the button on the PET Analysis Tool panel.
18. Click the upper left corner of the PET Analysis Tool panel to display the menu.
19. Click or drag to CLOSE to close the PET Analysis Tool panel.
20. Drag the Common Service Desktop back into view.
21. Click the upper left corner of the Common Service Desktop panel to display the menu.
22. Click or drag to CLOSE to close the Common Service Desktop.

Section 5. Scatter Fraction, Count Losses, and Randoms Measurement

The count losses and randoms portion of this test measures the count rate performance of the scanner across a range of radioactivity levels. The scatter fraction portion of this test measures the sensitivity of the scanner to coincidence events caused by scatter.

5.1 Acquisition Procedure

NOTE: This test requires a high amount of activity in a relatively small volume to measure the 3D peak NECR, to assess the count rate performance of the scanner.

5.2 Position the Phantom

1. Assemble the solid phantom sections as shown in Figure 5.1.

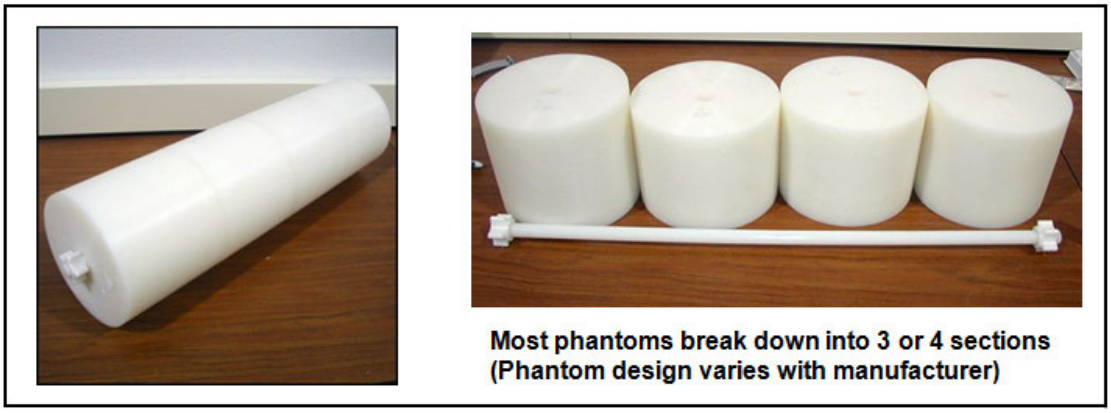


Figure 5.1: Example of a NEMA Scatter Phantom

2. Figure 5.3 shows the side view of the phantom and the shim inside the FOV. Do not use soft material as a shim because the phantom may sag during the log acquisition if soft material is used as a shim. Also, make sure that the center rod holding the phantom together is tight enough and there is no gap visible between the sections of the phantom. The line source should not be exposed to the scanner directly and hence, “no gap” between the parts of the NEMA scatter phantom is very important.
3. Also, make sure that the table characterization has been done properly and all the characteristics checks are done as described in Section 1.2 at the beginning of the document.
4. For positioning of the phantom refer to Figure 5.3. Insert shims (wooden blocks or stack of paper of thickness 4 – 6 cm). Raise the table to align the center of the phantom to the center of the scanner (laser alignment) maintaining the line source hole nearest to the surface of the cradle, as shown in the illustration.
5. It is recommended to use an auxiliary scan CT scan (SCOUT) to verify the position of the phantom:
    - Patient Orientation: Head First (Landmark: SN)
    - Group Type: SCOUT (2 scans: scout plane 0 and 90)

- Start location S400.00, end location I400.00,
- kV: 120 kV
- mA: 80 mA

6. Fix the position of the phantom according to the SCOUT scan. Make sure that the supporting shims are not in the FOV.
7. You may practice threading the line before injecting any activity into the log to see if it slides easily into place.

5.3 Prepare the Source

1. Volume of Line source is typically ~5.15 mL (70 cm long) (this line is thicker than the one used for NEMA sensitivity (2.3 mL), therefore it has a larger volume)

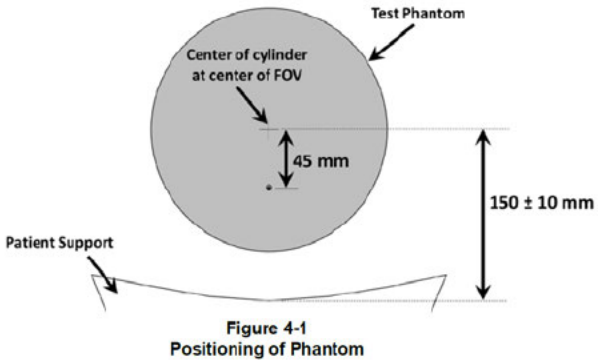


Figure 4-1
Positioning of Phantom

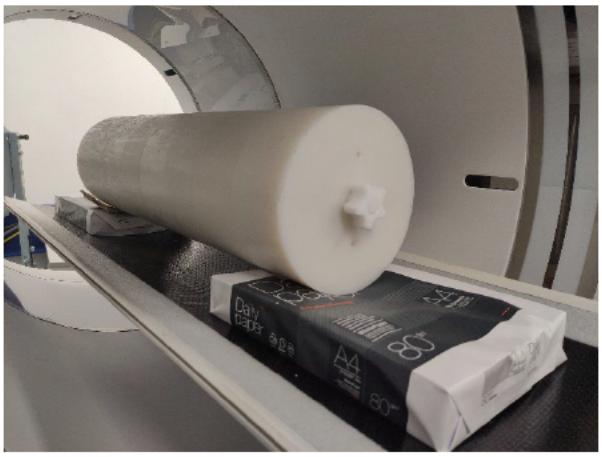


Figure 5.2: Line Source Orientation. Phantom shimmed on table.

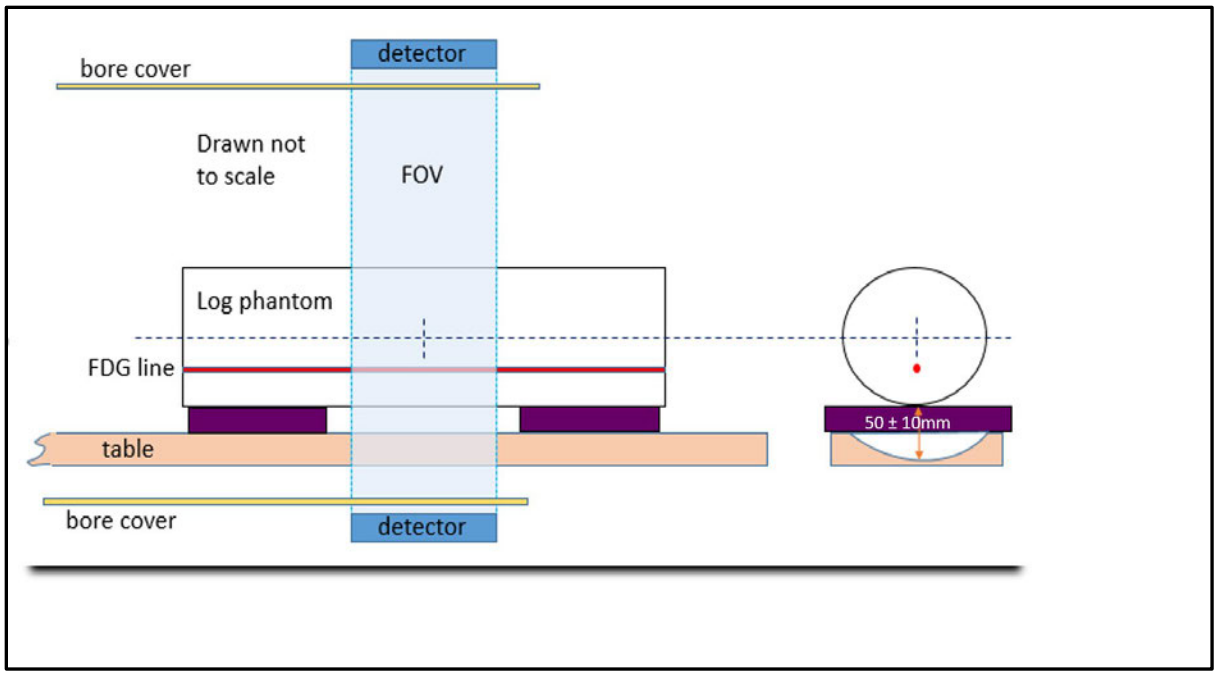


Figure 5.3 Side view and end view of the NEMA scatter phantom and shim relative to PET's FOV. Make sure that the supporting shims are not inside the scan FOV.

2. The Target is to create a diluted solution of >6.0 mL at 165 MBq/cc ($\boldsymbol{\rho_T}$ **= 165 MBq/mL**), i.e. total activity 800 to 850 MBq (21.6-23 mCi) calibrated to the time of scan including positioning.
3. Activity delivered by vendor at time of test $\boldsymbol{A_0}$ MBq
4. Volume delivered by vendor $\boldsymbol{V_0}$ mL
5. Volume of water to achieve target solution $\boldsymbol{V_w}$ mL
6. Label a 20 mL cold vial with "F18 and current date". Use scale to tare dry vial before measuring the following volumes.
7. Place water volume $\boldsymbol{V_w}$ in the vial (1mL = 1 gr), using the scale to measure:

$$\rho_T = \frac{A_0}{V_w + V_0} \quad \longrightarrow \quad \boldsymbol{V_w = \frac{A_0}{\rho_T} - V_0}$$

8. Dump the entire dose $\boldsymbol{A_0}$ from vendor's syringe into vial.
9. Add a color dye (very small drop <0.1 mL) to above dilution.
10. If total final volume is less than 6 mL (i.e. 6g) add water to make it 6 mL or larger; the resulting line source will have a concentration of less than 160 MBq/mL though.
11. Pull > 6mL into a 10 mL syringe.
12. Assay activity in syringe (with capped needle). This is the Pre-injection activity.
13. Fill line up to the 70 cm mark.
14. Close the open end of line with Critoseal (clay from Cha-Seal catalog No 510, Tube Sealing Compound)
15. Remove syringe and cap the end of the line.
16. Assay activity left over in syringe (with capped needle) Post-injection activity.
17. Refer to Figure 5.4. Insert the line source into the phantom.

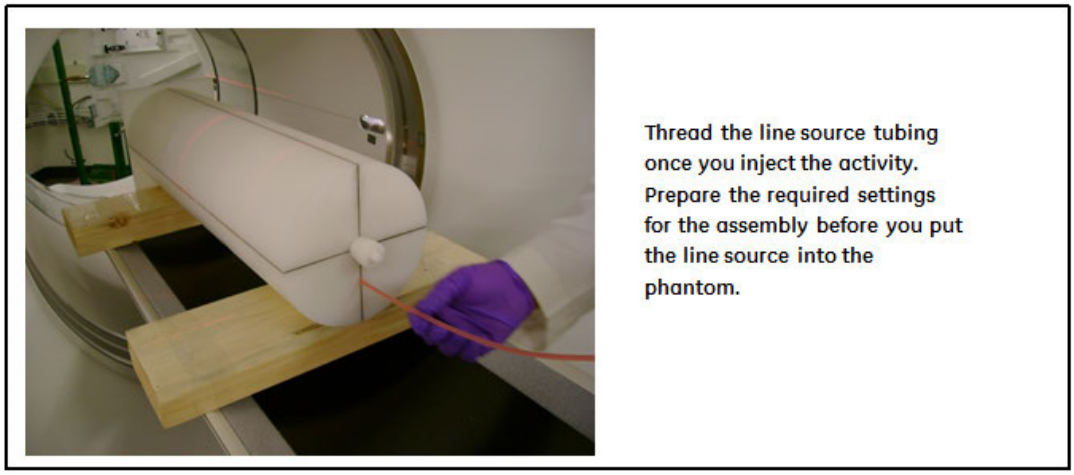


Figure 5.4: Thread the Line Source Tubing through the NEMA Phantom

NOTE: The precision of activity and time determination will directly influence the reported activity concentrations. The finite sampling periods also limit the reported concentration to the closest sample point.

5.4 Acquire the Data

1. If necessary, move the table base to the CT position.
2. Enable the alignment lights and center the phantom in the FOV.
3. Press the INTERNAL LANDMARK button to zero the gantry display.
4. Click NEW PATIENT to open the Patient Information screen.
5. Type/enter a Patient ID and Patient Name into the corresponding data fields to activate the Protocol Selection area.
    - Use an easily identifiable name, such as NEMA Decay
6. Click ENTER PET TRACER INFO to open the panel shown in Figure 5.5.
7. Enter the activity in MBq or mCi for each of the Pre-Injection and Post-Injection Assay data fields. Notice that volume is the phantom's volume of 22000 mL.
8. Enter the times and dates for both Pre- and Post-Injection assays.
    - The injection time MUST fall between the Pre and Post Injection times, even though this value will not be used in the calculation.
9. Click ACCEPT to close the panel.
10. If necessary, click the GE tab to select it.
11. Click beneath the Patient icon feet to display the Miscellaneous Protocol List.
12. Click the NEMA Decay protocol description to open the View/Edit screen.

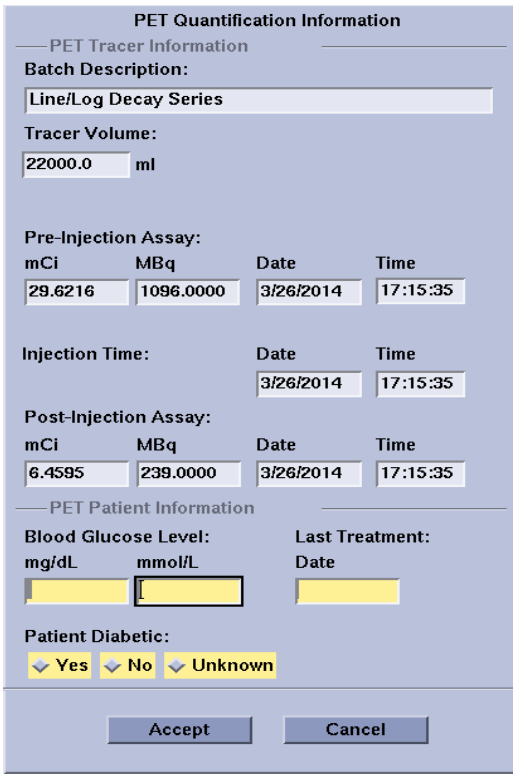


Figure 5.5: PET Tracer Information Panel

13. Acquire CT scan of the phantom.
14. Click PET to display the PET acquisition view/edit screen.
15. Click the DOSE tab to display the PET Tracer Information panel.
16. Click INHERIT FROM EXAM, or make sure the values agree with the values entered above in steps 6 to 8.
17. Click OK to close the PET Tracer Information panel.
18. Click on the PET RECON tab and verify the following parameters:
    - DFOV: 18 cm
    - Image size: 128 x 128
    - Recon Method: VPHD is the default (22 subsets, 3 iterations, filter cutoff 5mm)
    - Z-Axis filter: Heavy
19. Make sure activity in the line has decayed to a value between 800 MBq and 900 MBq. Click CONFIRM to initiate the first frame of the series. Note that in order to satisfy the NEMA requirement for this NECR decay series scan, the default protocol is designed in such a way that it contains the appropriate number of frames to take care of the appropriate total scan time.
20. Note that if the activity in the filled line is too high, it is likely that the acquisition system will throttle, i.e. limit the count rate to a fixed maximum. This can be observed even before the start of the acquisition when the count rate display shows a fixed rate and it does not change within a few seconds. In such a situation, wait to initiate the acquisition until count rate comes down

to below throttle. This can be observed when the count rate display (which showed a fixed number while above the throttle) starts showing rate values that change back and forth within a small range from each other.

21. Press the START SCAN button when it flashes to initiate this multi-hour dynamic scan. The protocol is designed to obtain sufficient count statistics for frames taken at high count rates, at peak NECR and at low count rates.
22. After the acquisition is complete, click END EXAM.

5.5 Analysis Procedure

Upon completion of the exam, follow the instructions in this section to use the PET Analysis Tool to calculate the results. **Note that the analysis takes approximately 2 hours.**

1. Click SERVICE to display the Common Service Desktop.
2. If necessary, click the PET radio button.
3. Click IMAGE QUALITY to display the tab contents.
4. Click NEMA ANALYSIS TOOL to open the PET Analysis Tool panel.
5. Refer to Figure 5.6. Click the COUNT LOSSES tab to display its button.
6. Drag the Common Service Desktop screen to the bottom of the monitor, to expose the Service browser located directly beneath it.
7. Click/highlight the NEMA Decay exam to select it.
8. Click/highlight the LIVE (901 or higher) series to select it (press Refresh Selection)
9. Refer to Figure 5.6. Click RUN CALCULATION.
    - After 2 hours approximately, the system displays a Scatter Fraction and Count Rate Results panel, similar to the one shown in Figure 5.7 .

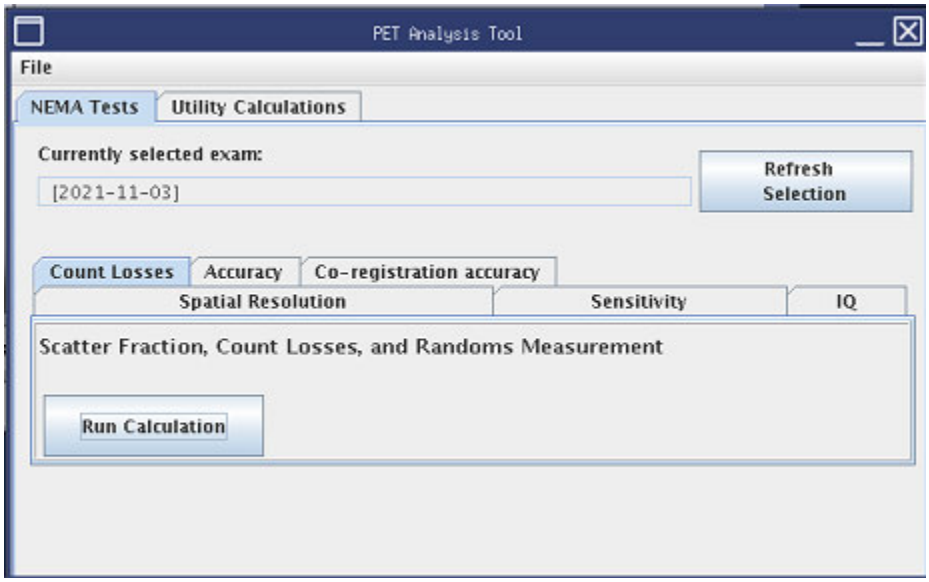


Figure 5.6: PET Analysis Tool - Count Losses Tab Selected

10. Compare the results to Table 9 and Table 10 in Section 8.
11. Refer to Figure 5.7. Record the activity value at peak NECR shown on your results screen, for use during Section 6.1 .
12. To print the results:
    a.) Click FILE in the toolbar of the Count Rate Curves panel.
    b.) Click or drag to PRINT to send a copy of the screen to the designated local printer.
13. To save the results to a file:
    a.) Click or drag to SAVE AS to display a browser similar to the one in Figure 2.11.
    b.) Select a destination folder.
    c.) Click the Files of Type bar and select a file type extension from the scrolling list.
    d.) Click SAVE to save the corresponding file type in the selected folder.
14. Click the upper left corner of the Count Rate Curves panel to display the menu.

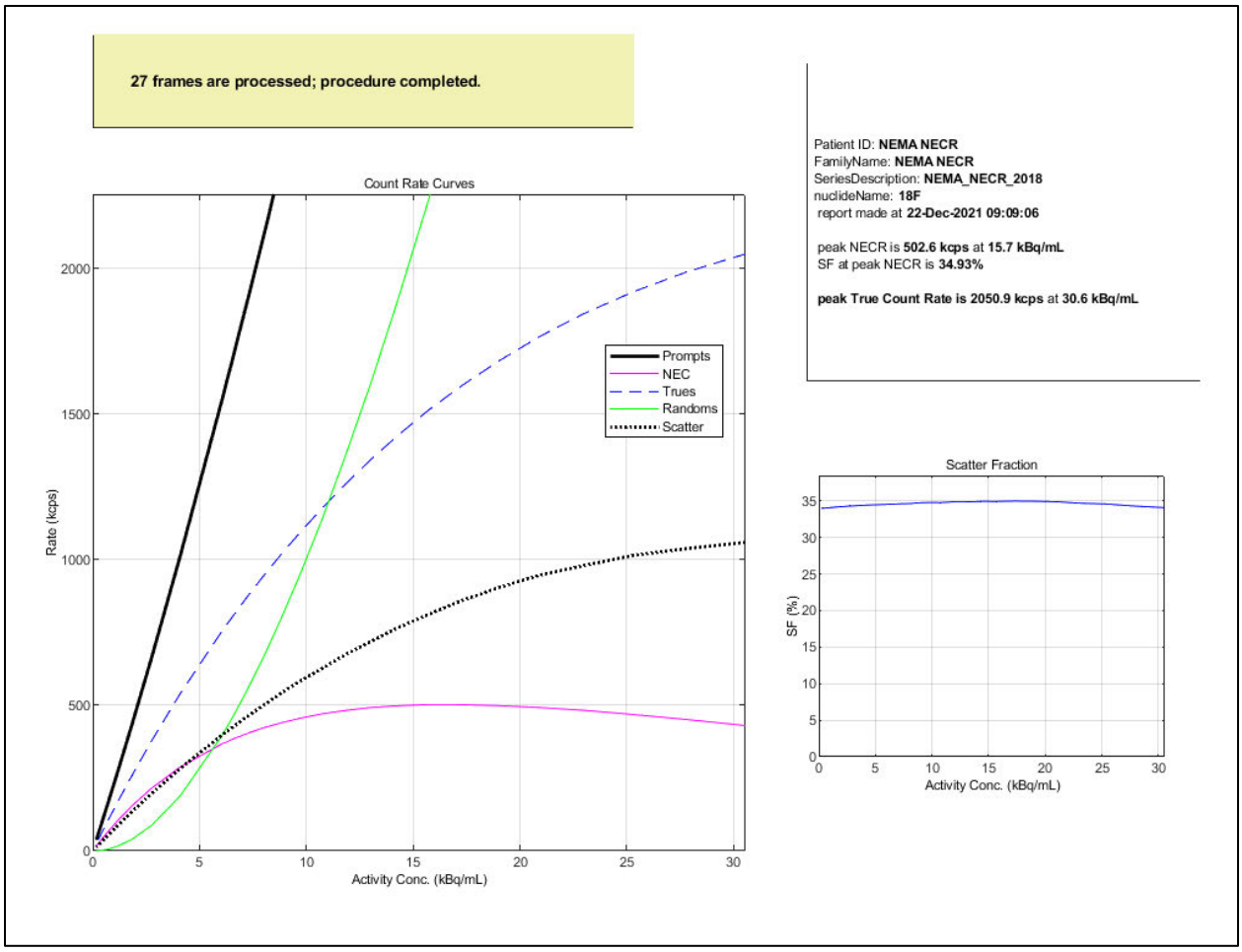


Figure 5.7: Example of Count Rate Results and Scatter Fraction for Omni Legend (32 cm axial FOV).

15. Click or drag to CLOSE to close the Count Rate Curves panel and activate the button on the PET Analysis Tool panel.

16. Click the upper left corner of the PET Analysis Tool panel to display the menu.
17. Click or drag to CLOSE to close the PET Analysis Tool panel.
18. Drag the Common Service Desktop back into view.
19. Click the upper left corner of the Common Service Desktop panel to display the menu.
20. Click or drag to CLOSE to close the Common Service Desktop.

Section 6. Accuracy: Correction for Count Losses and Randoms

Measures the accuracy of count losses and randoms corrections by comparing the trues rate calculated using count losses and randoms corrections with the trues rate extrapolated from measurements with negligible count losses and randoms. This test uses the Peak NECR value calculated in Section 5.

6.1 Analyze the Data

Upon completion of the decay series analysis (Section 5) follow the instructions in this section to calculate the Accuracy Correction of Count Losses and Randoms.

1. Click SERVICE to display the Common Service Desktop.
2. If necessary, click the PET radio button.
3. Click IMAGE QUALITY to display the tab contents.
4. Click NEMA ANALYSIS TOOL to open the PET Analysis Tool panel.
5. Click the ACCURACY tab to display its data field and button.
6. Drag the Common Service Desktop screen to the bottom of the monitor, to expose the Service browser located directly beneath it.
7. Click/highlight the NEMA Decay exam to select it.
8. Click/highlight the DYNAMIC image series to select it, and then press the REFRESH SELECTION button in the NEMA tool.

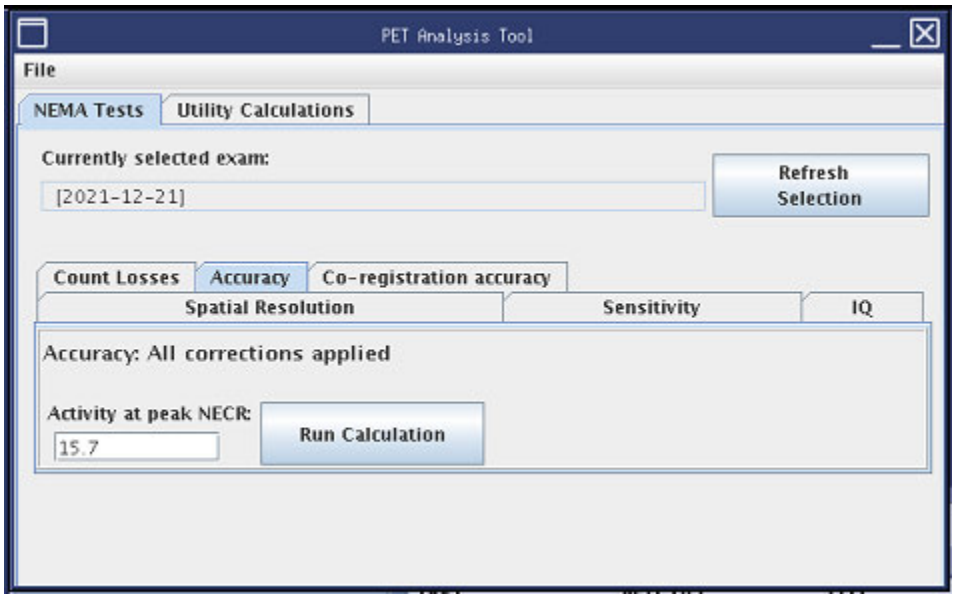


Figure 6.1: PET Analysis Tool - Accuracy Tab Selected

9. Refer to Figure 6.1. Type the activity value at Peak NECR value you recorded during Step 11 in Section 5.5 into the Activity at peak NECR data field.

10. Refer to Figure 6.1. Click RUN CALCULATION. After several minutes of calculation, the system displays a screen similar to the one shown in Figure 6.2.

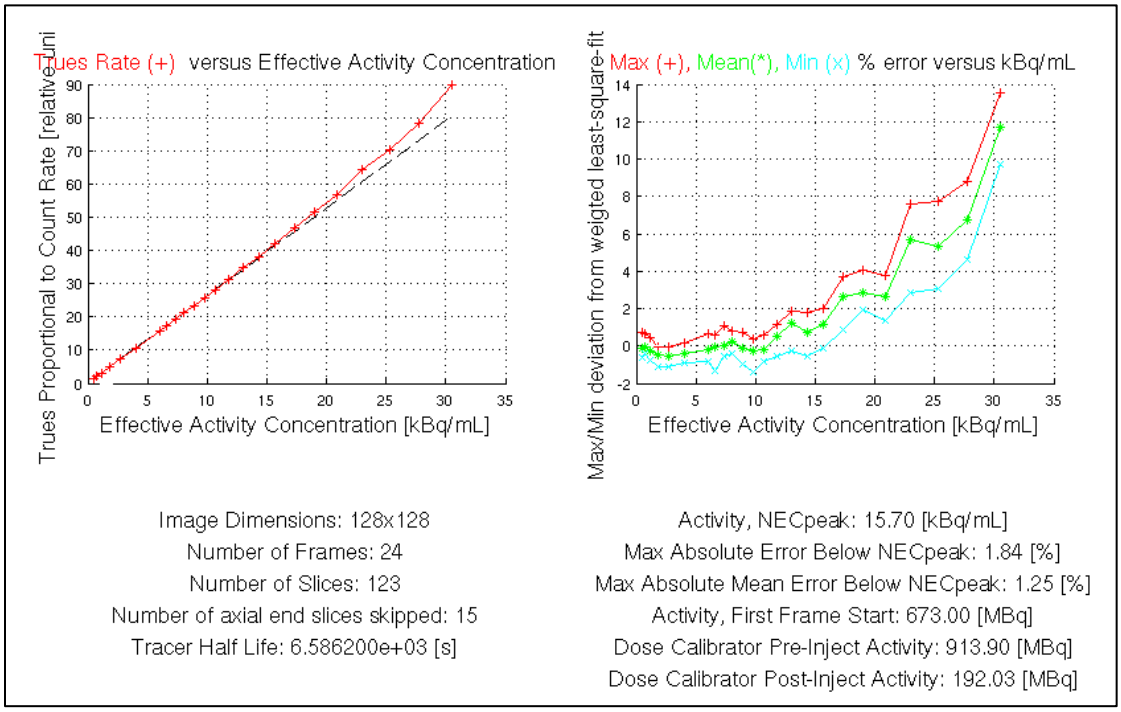


Figure 6.2: Count Loss Correction Accuracy Report obtained in Omni Legend (32 cm axial FOV).

11. Compare the Max Absolute Error Below NECpeak value to Table 11 in Section 8. The reported value should not exceed the value listed in Table 11.
12. To print the results:
    a. Click FILE in the toolbar of the Count Loss Correction Accuracy Report panel.
    b. Click or drag to PRINT to send a copy of the screen to the designated local printer.
13. To save the results to a file:
    a. Click or drag to SAVE AS to display a browser similar to the one in Figure 2.11.
    b. Select a destination folder.
    c. Click the Files of Type bar and select a file type extension from the scrolling list.
    d. Click SAVE to save the corresponding file type in the selected folder.
14. Click the upper left corner of the Count Correction Accuracy panel to display the menu.
15. Click or drag to CLOSE to close the Count Loss Correction Accuracy Report panel and activate the button on the PET Analysis Tool panel.
16. Click the upper left corner of the PET Analysis Tool panel to display the menu.
17. Click or drag to CLOSE to close the PET Analysis Tool panel.
18. Drag the Common Service Desktop back into view.
19. Click the upper left corner of the Common Service Desktop panel to display the menu.
20. Click or drag to CLOSE to close the Common Service Desktop.

Section 7. PET-CT Co-registration accuracy

The purpose of this measurement is to determine the co-registration error between PET and CT data. Data is acquired with PET and CT fiducial markers at 6 locations within the PET and CT field of view, with mass distributed on the patient handling system. Requirements are provided for the width of the distributions of the fiducial markers in the data. The centroids of the fiducial markers are calculated within the PET and CT data, and the co-registration error is determined by calculating the distance between the centroids.

7.1 Acquisition Procedure

The total activity in the spheres should be between 40MBq and 60MBq, to produce no more than 5% randoms, but sufficient to produce measurable results.

Tools required

1. PET – CT co-registration phantom holder (P/N 5837231).
2. 3 IEC (NEMA IQ) phantom hollow spheres 17 mm,22 mm and 28 mm.
3. CT contrast solution (i.e. Iopromide or Ioxitalamic acid).
4. Weights with nominal mass 115 kg ± 2.5 kg (253.5 ± 5.5 lbs) that can be distributed on the patient table in two parts of 50 ± 5 %, each evenly distributed over ~65 cm.

NOTE: Some CT contrast media might crystalize inside the spheres if left overnight, leaving the residue that cannot be cleaned inside the spheres.

Prepare the Source:

1. Draw ~60MBq of F-18 into a syringe.
2. Empty the syringe into a container and fill the container with water to 14 cc.
3. Draw 6 cc of CT contrast medium into a syringe.
4. Empty the syringe of CT contrast into the above container of the diluted activity.
5. Mix well the contents of the container to achieve a homogenous solution.
6. Draw the PET-CT solution into a syringe.
7. Fill each of the three spheres/markers with the PET-CT solution from the syringe.
8. Fasten the spheres/markers to the PET-CT co-registration fixture/holder: 17 mm sphere at position (0,1), 22 mm sphere at position (0,20), and 28 mm sphere at position (20,0).

Figure 7.1: PET-CT co-registration holder. The table pad should be removed during the measurement.

7.2 Position the Phantom

1. Refer to Figure 7.2. Distribute the mass, such as weight plates or sandbags, totaling 57.5 kg evenly over 65 cm, from 20 cm from the tip of the table. If you use sandbags be careful not to get the sand in the tables sliding rails.
2. The remaining mass should be evenly distributed over 65 cm, between 115 cm and 180 cm from the tip of the table. Refer to Figure 7.2.

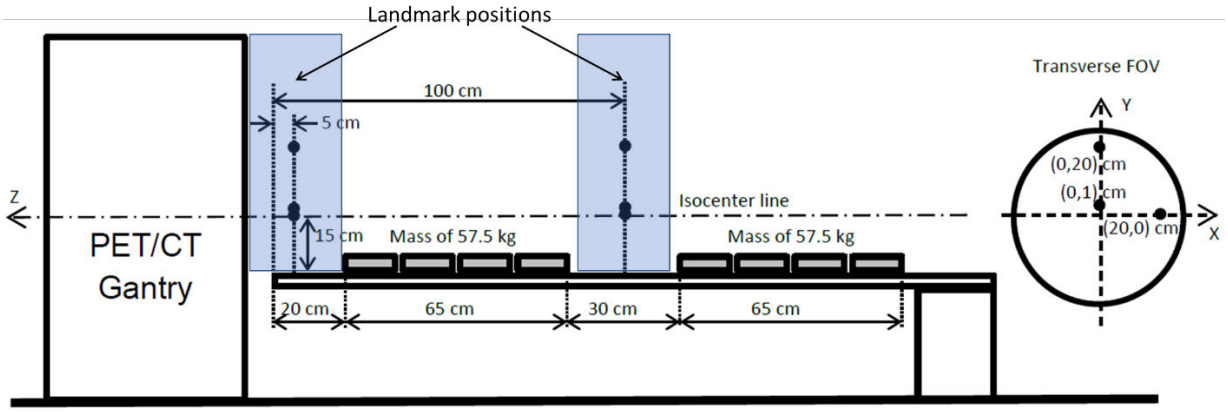


Figure 7.2: Phantom position in the scanner – blue boxes represent 2 different landmark positions. Make sure that the weights are not inside scan FOV.

3. Adjust the table height to 150 ± 10 mm below the FOV center.
4. Position the fixture/holder on the cradle at 5 ± 2 cm from the tip in the position for the first CT and PET scan.
5. Move the table base to the CT position.
6. Press the CT alignment light button to turn on the lasers.
7. Center the spheres/markers in the sagittal and coronal planes such that:

   - In the axial plane, the laser should align with the scribed vertical line on the phantom/fixture's main plate.
   - In the coronal plane, the laser should align with the scribed horizontal line on the side phantom/fixture's main plate
   - Press the INTERNAL LANDMARK button to zero the gantry display.

7.3 Data acquisition

1. Click the *EXAM RX* icon to open the PET-CT acquisition screen.
2. Click *NEW PATIENT* and fill in the following data fields:
3. Patient ID: NEMA PET-CT Coreg
4. Patient Name: NEMA IQ PET-CT Coreg
5. Operator: your initials
6. Click ENTER PET TRACER INFO to open the panel shown in Figure 7.3.
7. Enter the activity in MBq or mCi for each of the Pre-Injection and Post-Injection Assay data fields.
8. Enter the times and dates for both Pre- and Post-Injection assays.
9. Click ACCEPT to close the panel.
10. Click the *GE* tab above the patient illustration to access the corresponding protocols.
11. Click beneath the illustrated patient's feet to display a list of protocol selections.

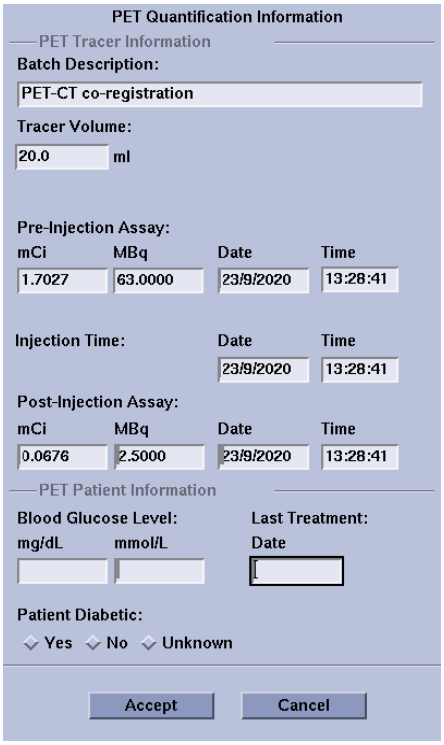


Figure 7.3: PET Tracer Information Panel

Attention: The scan protocol has 2 different landmark positions included. Please do not end the scan after the PET scan in the first position.

12. Select the *NEMA PET-CT Co-registration* protocol to open the corresponding view/edit screen.
13. Click *CONFIRM* to initialize the first scout scan.
14. Upon completion of the scout acquisition, click *NEXT SCAN*.
15. Use the Localizer (*Graphic Rx*) to position the centering cross directly over the spheres in the phantom/fixture. Make sure that the weights are not inside scan FOV.
16. Verify the CT series prescription contains the following parameters:
    - Patient Orientation: Head First (Landmark: SN)
    - Thick Speed: 3.75, 39.37, 0.984:1
    - Scan Type: Helical, Full, 0.5 sec.
    - kV: 140 kV
    - mA: Auto (under software control)
    - Recon DFOV: 50 cm
    - Recon Type: PET AC, wide View
17. Click *CONFIRM* to initiate the CT scan sequence.
18. Upon the completion of the CT scan, click *PET* to open the acquisition screen.
19. Verify the PET prescription screen contains the following parameters.

- Scan Type: Static, ViP off
- Scan Direction: Head first
- Scan Time:
    - 00:04:00 (4 minutes) for Omni Legend (32 cm Axial FOV)
    - 00:07:00 (7 minutes) for Omni Legend (16 cm Axial FOV)

20. Click on the *RECON* Tab and verify the screen has the following parameters:
    - Image Size: 384 x 384
    - Recon Method: VPHD
    - Recon FOV: 50cm
    - Subsets/Iterations: 22/6
    - Filter cutoff: 2
21. Click *CONFIRM* to initiate the PET scans. Please do not end the scan after the first PET scan.
22. **Upon completion of the first PET scan move the phantom holder to the second position at 100 ± 2 cm from the tip of the table.**
23. Move the Table base to the CT position.
24. Press the CT alignment light button to turn on the lasers and align the phantom according to step 7.
25. Click *NEXT SCAN* to initialize second scout scan.
26. Repeat steps 14 through 21 for second CT and PET position.

7.4 Analysis procedure

1. Click SERVICE to display the Common Service Desktop.
2. If necessary, click the PET radio button.
3. Click IMAGE QUALITY to display the tab contents.
4. Click NEMA ANALYSIS TOOL to open the PET Analysis Tool panel (Figure 7.4).
5. Click the CO-REGISTRATION ACCURACY tab to display its data field and button.
6. Drag the Common Service Desktop screen to the bottom of the monitor, to expose the Service browser located directly beneath it.
7. Click/highlight the NEMA PET-CT Co-registration exam to select it.
8. Click/highlight the two CT and two PET image series to select them, and then press the REFRESH SELECTION button in the NEMA tool.
9. Refer to Figure 7.4. Click RUN CALCULATION.
   After several minutes of calculation, the system displays a screen similar to the one shown in Figure 7.5.

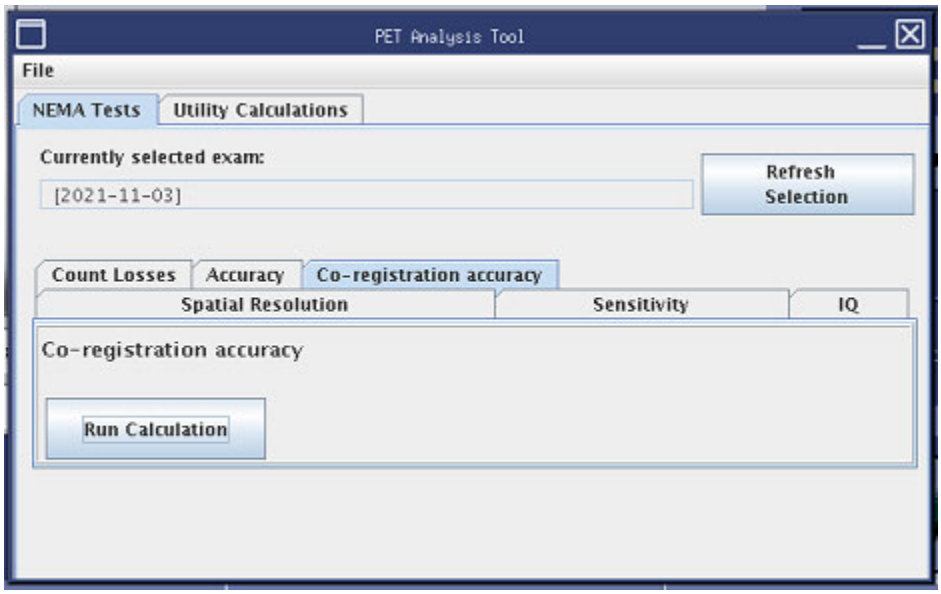
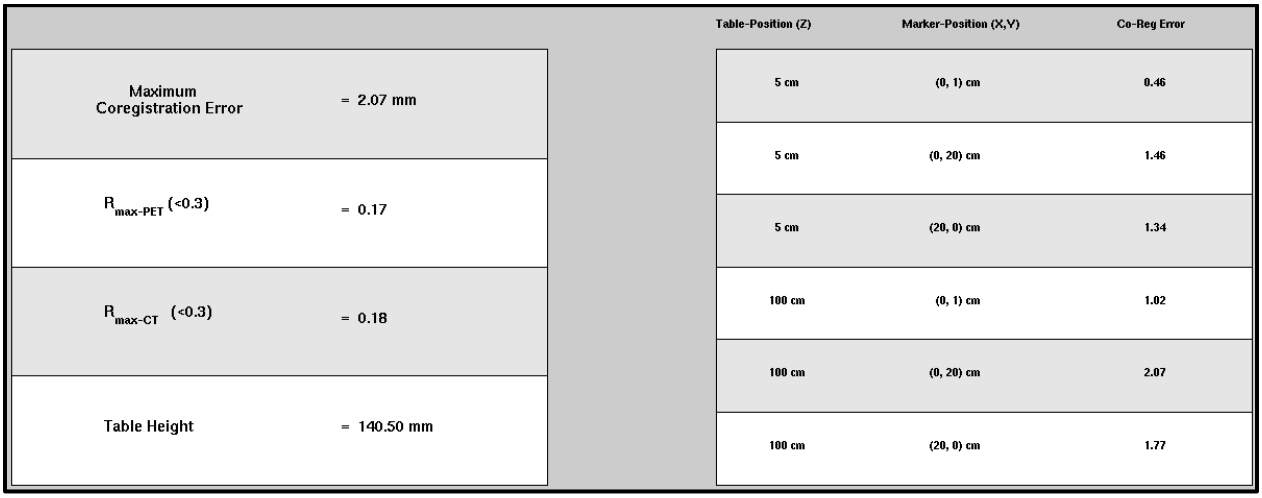


Figure 7.4: PET Analysis Tool – PET-CT co-registration tab selected



Maximum Coregistration Error	= 2.07 mm
$R_{max\text{-}PET}$ (<0.3)	= 0.17
$R_{max\text{-}CT}$ (<0.3)	= 0.18
Table Height	= 140.50 mm

Table-Position (Z)	Marker-Position (X,Y)	Co-Reg Error
5 cm	(0, 1) cm	0.46
5 cm	(0, 20) cm	1.46
5 cm	(20, 0) cm	1.34
100 cm	(0, 1) cm	1.02
100 cm	(0, 20) cm	2.07
100 cm	(20, 0) cm	1.77

Figure 7.5: PET-CT Co-registration Report (example for Omni Legend 32 cm)

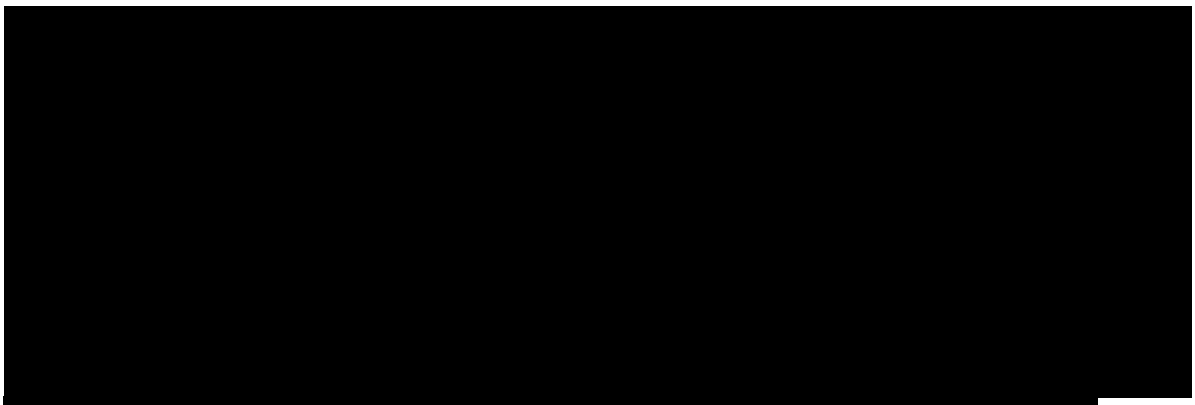
10. Compare the Maximum Co-registration Error to the value in Table 16 in Section 8. The reported value should not exceed the value listed in Table 16.
11. To print the results:
    a.) Click FILE in the toolbar of the Count Loss Correction Accuracy Report panel.
    b.) Click or drag to PRINT to send a copy of the screen to the designated local printer.
12. To save the results to a file:
    a.) Click or drag to SAVE AS to display a browser similar to the one in Figure 2.11.
    b.) Select a destination folder.
    c.) Click the Files of Type bar and select a file type extension from the scrolling list.
    d.) Click SAVE to save the corresponding file type in the selected folder.

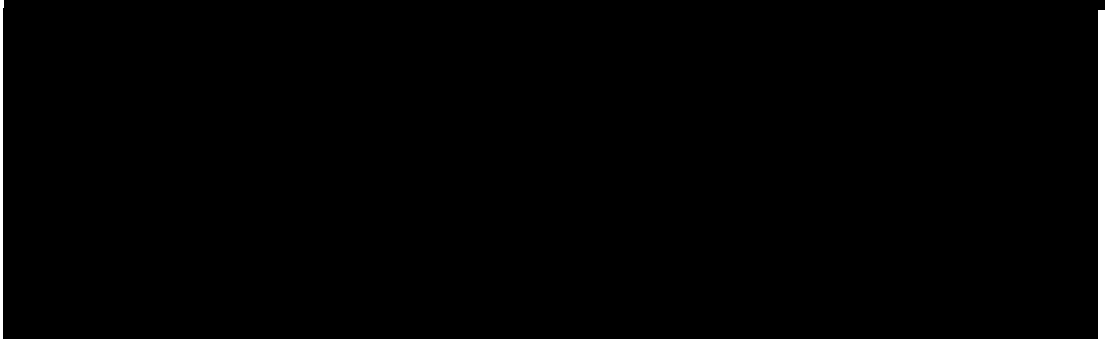
Section 8. Performance Specifications

When fully installed, a new system should meet the performance specifications listed in Table 6 through Table 14 provided, it has been tuned (per Service Methods) and carefully tested, as described in this document. The tests in this document expect a system that has full covers and is well aligned. Make sure the system has been powered on for at least 24 hours to stabilize the system to the environment. Carefully follow the procedures in this document to prepare the source, acquire data, and analyze the results as described in this document. Additional values are reported on test reports per NU2 standard. These values are for information only and are not compared to a performance specification.

All measurements and performance specifications listed in this document that require F18 were performed as per NIST dose calibrator recommendations in **Fitzgerald, R.,** et al. **"A new NIST primary standardization of ^{18}F."** ***Applied Radiation and Isotopes*** **85 (2014): 77-84.**

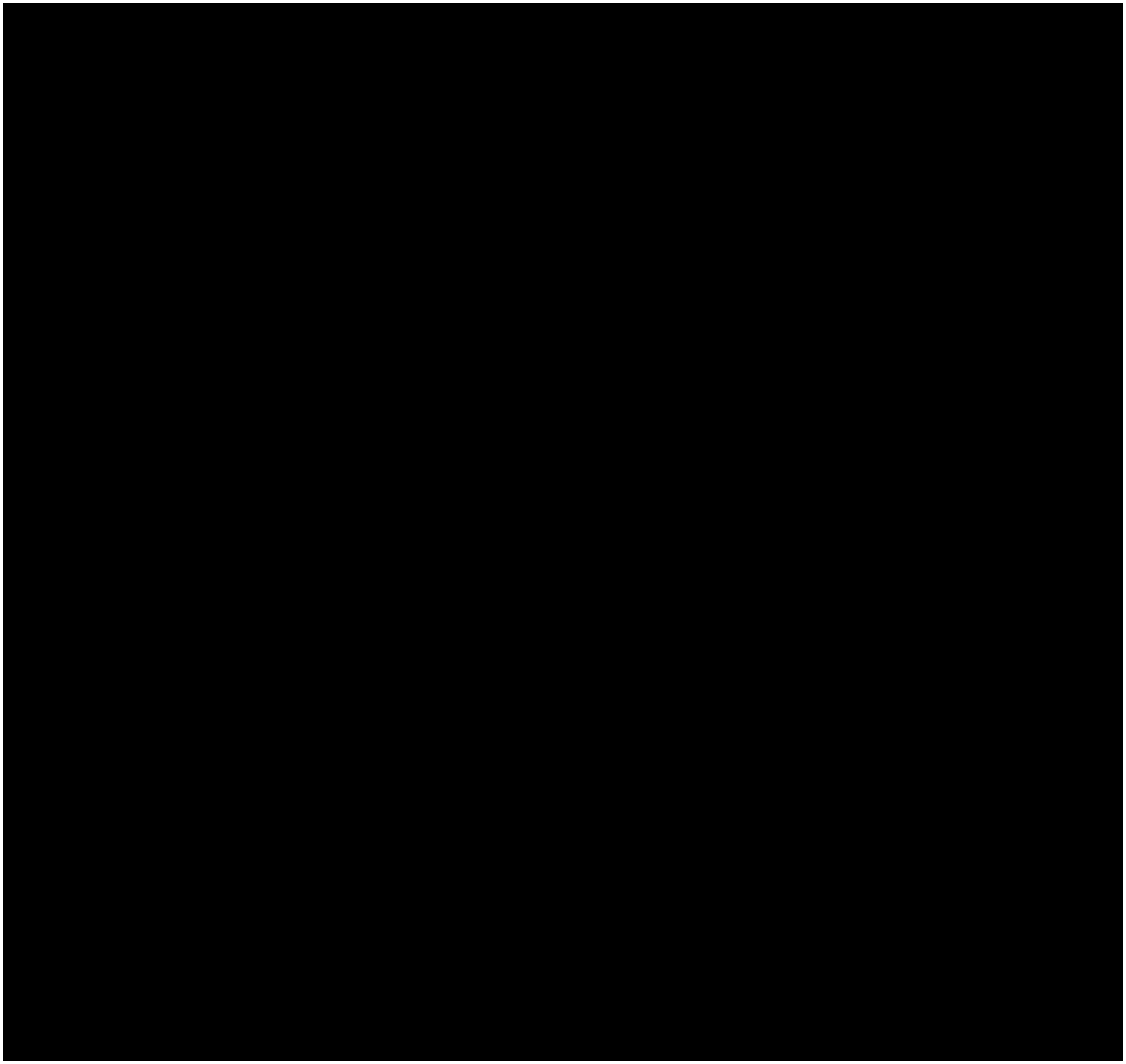
8.1 Spatial Resolution Test Results





[redacted]

Background								
[redacted]								



Section 9. Detector Performance Test

9.1 Energy Resolution

Radiation Source: Annulus phantom used for calibration, mounted on its holder at the end of the table.

Use the energy and timing resolution tool "*Detector Performance Tool*" (DPT), provided with the scanner to calculate the scanner's average energy resolution. This test uses the annulus phantom used for system calibrations and DQA.

It is very important to execute the following instructions in the prescribed order. The DPT evaluates the most recent calibrations to calculate energy and timing resolution. Running DQA or a new calibration will affect the results.

Energy Resolution acquisition:

Calibrate the scanner using the annulus phantom. Make sure the gain calibration meets the limits for convergence.

Energy resolution calculation:

1. Open Linux terminal window.
2. Type
   DetPerfTool –R (it is located in /usr/PET/release/dragon/bin/linux2/)
3. The average energy resolution and timing resolution of the scanner is displayed on the screen.
4. **Energy resolution limit:** The Maximum energy resolution averaged over the scanner (Avg energy resolution of the device) using the FDG line is 11.5%

Appendix 1 Spatial Resolution with FFBP Reconstruction

This appendix is applicable to all the Omni Legend Series products:

Omni Legend (32 cm Axial FOV)

Omni Legend (16 cm Axial FOV)

NOTE: The NEMA resolution protocol used in Section 2 (Spatial Resolution**) presented in this manual reconstructs images using the VPHD reconstruction algorithm. The Fourier Filtered Back Projection (FFBP) reconstruction method is also available and the steps to execute it are provided in this Appendix.**

1. In order to produce FFBP reconstructed images of point sources, the user must follow the procedure described in Section 2 first. This includes preparation of the sources, alignment in the FOV, and data acquisition as described in that section. It will automatically proceed to prospectively reconstruct the images using the VPHD algorithm.
2. Once the data sets have been acquired, proceed to reconstruct the same sinograms (raw data) retrospectively. Start retrospective reconstruction from the [PET Recon/Replay] button at the screen. Use the [Point Source Recon] protocol, located under the same tab (GE) that contains the "NEMA resolution protocol executed in step 1.
3. Proceed to analyze the new images using the PET Analysis tool, as described in section 2.4
4. The spatial resolution upper limits are presented in Table 7 (Section 8).

References

[1] Fitzgerald, R., et al. "A new NIST primary standardization of ^{18}F." *Applied Radiation and Isotopes* 85 (2014): 77-84.

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