11.6.4 Single Crystal Scintillation Camera Test Methods for Single Photon Emission Computed Tomography: Performance Standards and Class Standards (optional)

Suggested QC tests which you should perform according to the NEMA protocol in this training:

- Spatial Resolution
- Reconstructed Spatial Resolution without Scatter
- Reconstructed Spatial Resolution with Scatter
- Uniformity
- Reconstructed Image Uniformity
- Sensitivity
- System Volume Sensitivity

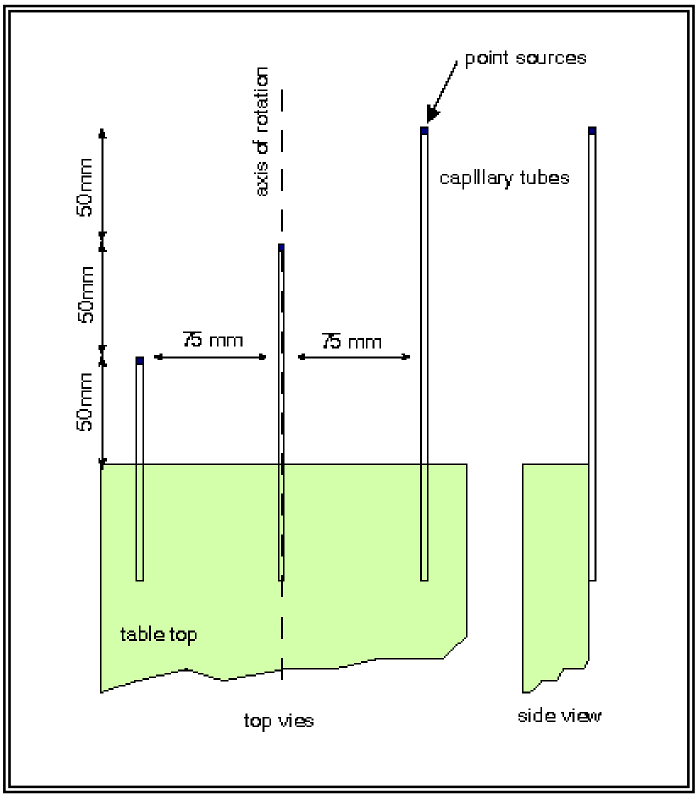
Discuss with your tutor which of the tests that you should concentrate on.

Reconstructed Spatial Resolution <u>without</u> Scatter

This performance standard parameter shall be measured of 3 specified points in air, and is reported as FWHM in the X, Y and Z direction for these points.

Equipment

The radionuclide is $^{99}Tc^{m}$ (or ^{57}Co) and as usual, the count rate shall be below 20 000 s^{-1} in a 20% symmetric energy window. Small point sources, not exceeding 2 mm, shall be made as spherically symmetric as possible, by using thin-walled capillary tubes positioned as described in the figure.



Measurement

The plane of the 3 point sources shall be positioned parallel to the plane of the table, with the central point source positioned on the axis of rotation and centred in FOV ± 5 mm. The radius of rotation for a circular orbit shall be 150 ± 5 mm. The reconstructed image shall be in a matrix with an effective pixel size of ≤ 2.5 mm. The acquisition should be made with ≥ 20 000 counts in each of at least 120 different projections angles over 360° utilising "step and shoot" mode.

Calculation
One transverse slice, 130 ± 5 mm thick, centred on the central point source, shall be reconstructed using the filtered back projection technique and a ramp filter. Three point source should be seen in this transverse slice.

One sagital slice, 180 ± 5 mm thick, centred on the central point source shall be reconstructed as above.

Analysis
Each of the nine point sources shall be analysed individually with a ROI (squares with dimensions ≥ 4 FWHM) centred on the maximum count pixel of the source. For each point image the point spread function should be determined, and the FWHM in X and Y direction shall be calculated:

Central Point Measurements			
Transverse slice	X =	Y =	
Sagital slice		Y =	Z =
Coronal slice	X =		Z =
Average	$\overline{X}$ =	$\overline{Y}$ =	$\overline{Z}$ =
Transaxial average	$\frac{\overline{X}+\overline{Y}}{2}$ =		

Peripheral Point Measurements			
Source 1			
Transverse slice	X =	Y =	
Sagital slice		Y =	Z =
Coronal slice	X =		Z =
Source 2			
Transverse slice	X =	Y =	
Sagital slice		Y =	Z =

Coronal slice	X =		Z =
Average	$\overline{X}$ =	$\overline{Y}$ =	$\overline{Z}$ =

Results

FWHM average values

Central Transaxial $\left(\frac{\overline{X}+\overline{Y}}{2}\right)$	
Central Axial (Z)	
Peripheral Radial ($\overline{X}$)	
Peripheral Tangential ($\overline{Y}$)	
Peripheral Axial ($\overline{Z}$)	

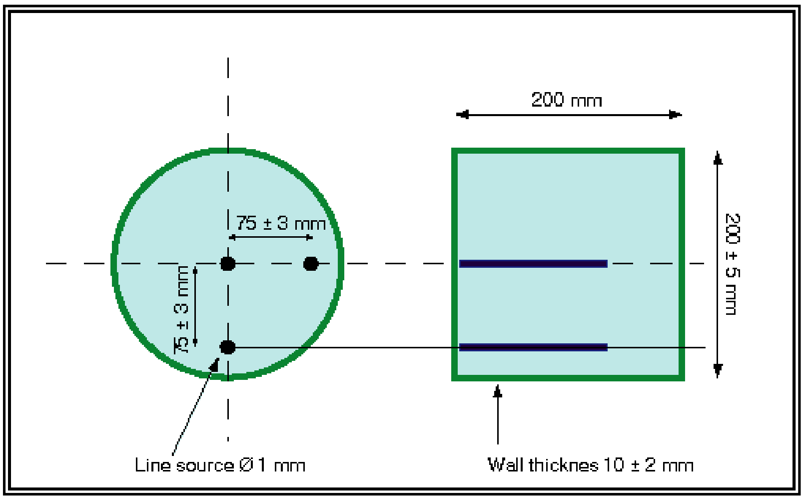
NOTES AND DISCUSSION

Reconstructed Spatial Resolution with Scatter

This class standard expresses the reconstructed transaxial spatial resolution measured using three line sources in a cylindrical water phantom. It shall be reported as FWHM values in mm, for a central source and for two peripheral sources, radial and tangential direction respectively.

Equipment

The radionuclide is $^{99}Tc^{m}$ (or ^{57}Co) and as usual, the count rate shall be below 20 000 s^{-1} in a 20% symmetric energy window. The phantom is a water filled Perspex cylinder with an inside diameter of 20 mm and containing three axial line sources with diameter of 1 mm, figure 11. X.

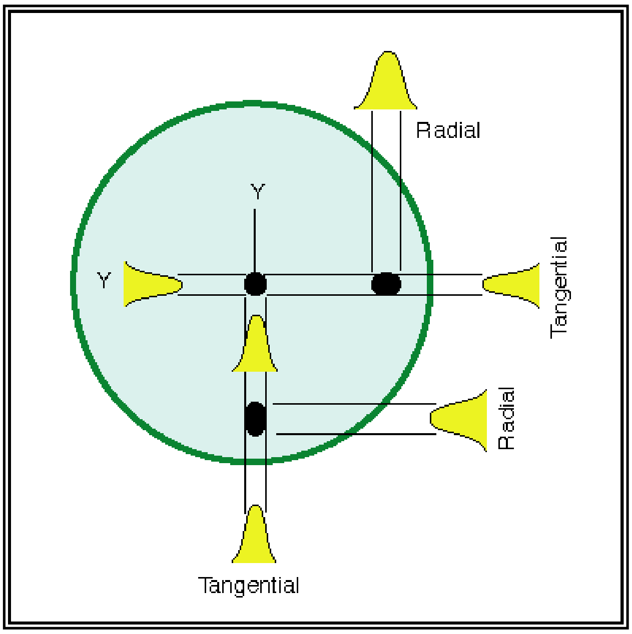


Measurement Procedure

The phantom shall be centred in FOV and aligned with the axis of rotation ± 2 mm. The SPECT acquisition mode shall be a 360° circular orbit of a radius of 150 ± 5 mm. At least 100 000 counts should be acquired in each of at least 120 different projection angles utilising “step and shoot” mode. The reconstructed image shall be in a matrix with an effective pixel size of ≤ 2.5 mm.

Calculations

Reconstruct through the centre of the phantom, using filtered back projection and a ramp filter, one transverse slice with a thickness of10 ± 3 mm. In addition, two transverse slices shall be reconstructed and centred about ± 40 mm from the centre along the axis of rotation. The analysis of the reconstructed images shall be performed as in 0.



Calculate the average FWHM radial value, figure 11. , of the six radial measurements on the three slices of the two peripheral source. Repeat this calculation for the tangential measurements on the images, *i.e.* average tangential FWHM values. The average of the six measurements for the three images of the centre source shall also be calculated.

Report the reconstructed spatial resolution with scatter as FWHM resolution in mm (± 0.1 mm), for a central source and for two peripheral sources (one for the radial direction and one for the tangential direction).

NOTES AND DISCUSSION

System Volume Sensitivity

This is a class standard, which shall be measured using a cylindrical phantom and the average volume sensitivity per axial centimetre shall be determined. The parameter is defined as the total system volume sensitivity to a uniform concentration of activity of a specific cylindrical phantom. It is dependant of

- detector configuration
- collimator type
- gamma energy
- energy window width
- source configuration and other factors

The count rate for each projection image shall be below 10 000 ± 2000 s^{-1} in a 20% symmetric energy window. The phantom required is a water filled Perspex cylinder with a inside diameter of 200 ± 5 mm, 200 ± 2 mm in length and a wall thickness of 10 ± 2 mm. The phantom shall be positioned in the centre of the FOV with its axis parallel to axis of the rotation (± 5 mm).

A SPECT acquisition in a circular orbit (360°) with a radius of 150 ± 5mm, and 120-128 different acquisition angles shall be performed. Each acquisition angle shall contain 100 000 ± 20 000 s^{-1}. For two and three head cameras, the images from all detectors may be summed. No corrections for non-uniformity's shall be performed. The total acquisition time for shall be measured.

CALCULATION AND ANALYSIS

The system volume sensitivity, *SVS*, is calculated by

$$SVS = \frac{\dot{N}}{A_C} \left[\mathrm{s}^{-1}\ \mathrm{kBq}^{-1}\ \mathrm{cm}^{3} \right]$$

where $\dot{N}$ is the average cps per elapsed time for the acquisition [s^{-1}] and A_C
is the activity concentration [kBq cm^{-3}] in the phantom with a specific volume [cm^{-3}].

The volume sensitivity per axial centimetre, *VSAC*, is calculated by

$$VSAC = \frac{SVS}{L}\ [\mathrm{s}^{-1}\ \mathrm{kBq}^{-1}\ \mathrm{cm}^{2}]$$

where L is the axial length of the phantom, given in cm (20cm). The sensitivity should be given for each radionuclide (energy) and collimator used in the SPECT imaging, and for the acquisition mode.