Quality Assurance in Gamma Camera

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Factors affecting image formation

- Distribution of radiopharmaceutical
- Collimator selection and sensitivity
- Energy resolution
- Uniformity
- Spatial resolution
- Count rate performance
- Center of rotation misalignment
- Patient motion
- Attenuation

Quality Control Practices

- Daily QC
  - Energy Peaking
  - Uniformity: Extrinsic or Intrinsic flood
  - Sensitivity Measurement
- Weekly QC: with PLES or four-quadrant bar phantom.
  - Spatial Resolution, Linearity : Extrinsic or Intrinsic
  - Pixel size
- Monthly QC
  - High count Uniformity calibration (200 million count)
  - C.O.R. (center of rotation)

ICANL (Intersocietal Commission for the Accreditation of Nuclear Medicine)
ACR (American College of Radiology)

Daily QC

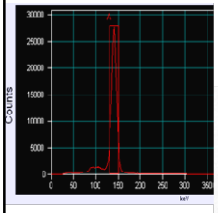
- Energy Peaking
- Uniformity: Extrinsic or Intrinsic flood
- Sensitivity Measurement

Daily QC

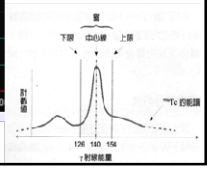
- Peak: daily for ^{57}Co, ^{99m}Tc, & other isotopes to be used that day.
- Uniformity: Flood images of 15-30 million counts each day of use, before imaging begins.
  - Extrinsic flood image is preferred and tests heavily used collimators.
  - Intrinsic flood image to test detector only, especially at the periphery of the FOV.

Peak

Energy Peaking



Tc99m



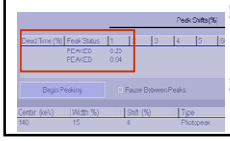
Energy Peaking

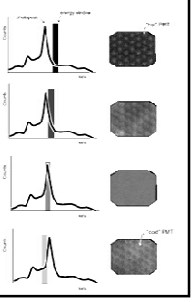
Peak shift value: ± 3%

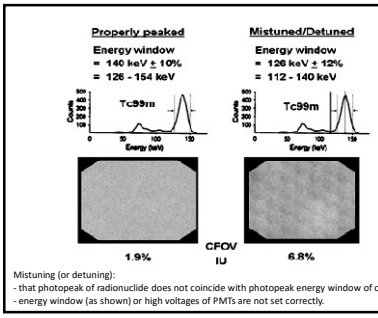
Source dose: 25-35μci,

count rate range: 40-80 kcounts/sec

Dead time: 3-10%.

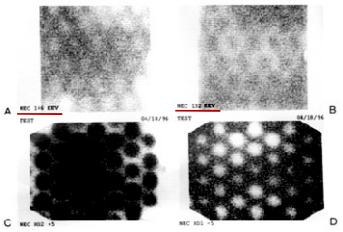






Mistuning (or detuning):
- that photopeak of radionuclide does not coincide with photopeak energy window of camera
- energy window (as shown) or high voltages of PMTs are not set correctly.

Effect of improper energy peaking

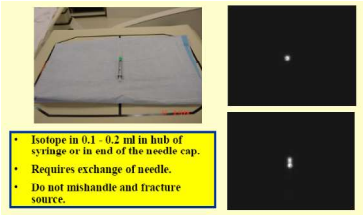


Uniformity

Uniformity Correction is a Calibration

- **Intrinsic Calibration requires**
  - **Precise point source background and scatter free**
  - **Correct count rate**
- Extrinsic Calibration
  - Planar flood source
  - Required for each collimator
  - Includes intrinsic calibration

Point Sources



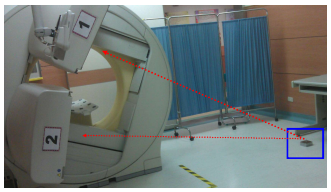
- Isotope in 0.1 - 0.2 ml in hub of syringe or in end of the needle cap.
- Requires exchange of needle.
- Do not mishandle and fracture source.

Flood Source

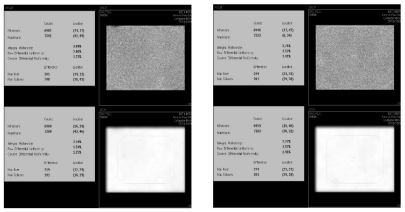
^{57}Co Flood Source – $T_{1/2}$ 270 days; 122 keV γ; 10-15 mCi at time of purchase.

^{99m}Tc Flood Source (water filled) – $T_{1/2}$ 6 hrs.; 140 keV γ; 10-15 mCi at time of filling.

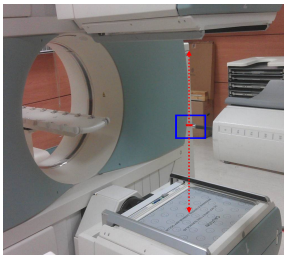
Measuring Intrinsic Uniformity



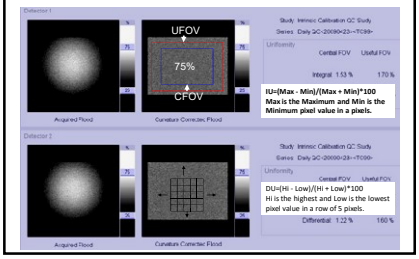
Intrinsic Uniformity

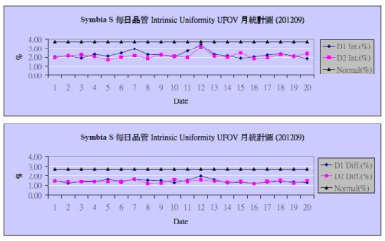


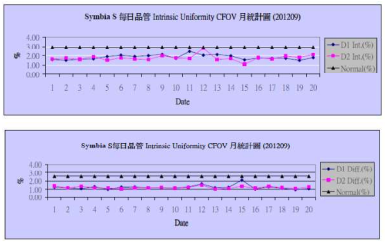
Measuring Intrinsic Uniformity



Daily QC - Intrinsic Uniformity



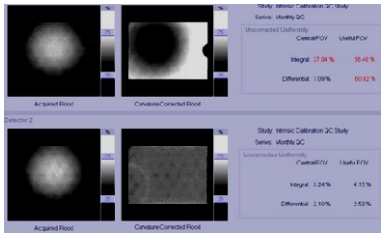


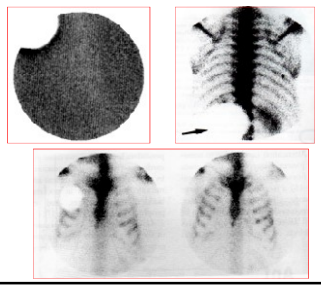


Unusual images

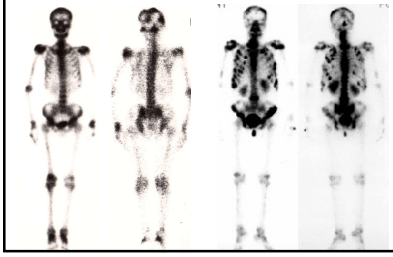
Sensitivity Measurement

Non-Uniformity from PMT

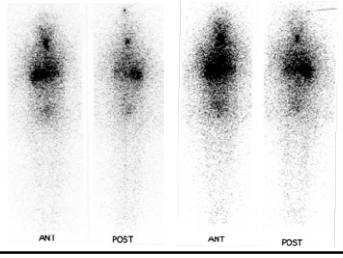




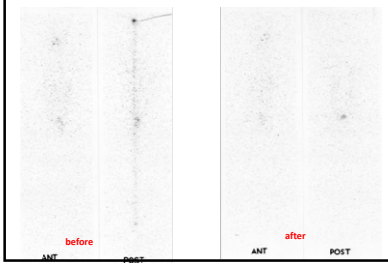
PM Tube error



Contamination

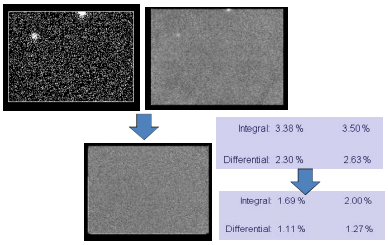


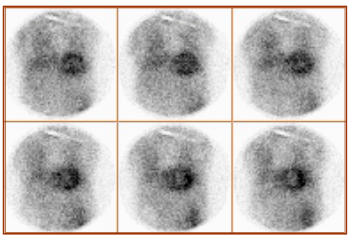
Contamination



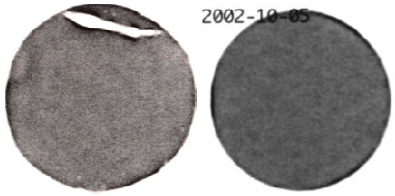
Contamination – QC error

Contamination

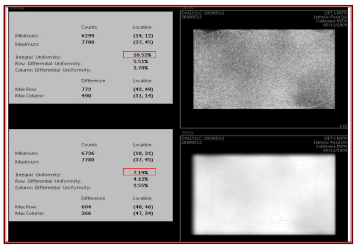




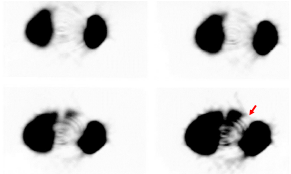
Crystal damage



Intrinsic Uniformity



Bullseye Ring Artifact- nonuniformity



Severe ring, or bull's-eye, artifact in transverse SPECT image through 20-cm diameter 99mTc-filled cylinder phantom resulting from gross γ-camera nonuniformity

Weekly QC

- Spatial Resolution, Linearity

Spatial resolution

Spatial Resolution

- Providing images sharpness or detail.
- Factors affecting spatial resolution include:
  - collimator resolution (the main factor in nuclear medicine). System sensitivity requires certain diameter of the collimator holes etc.
  - intrinsic resolution (due to the statistical variation which is photon energy dependent).

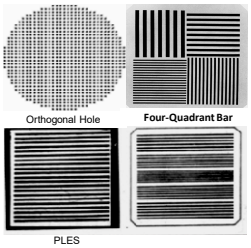
Methods for Evaluating Spatial Resolution

- Organ phantom measurement (qualitative) such as brain phantom.
- Bar phantom measurement (quantitative). There are a number of phantoms: four quadrant bar phantom, parallel-line phantom, orthogonal hole phantom.

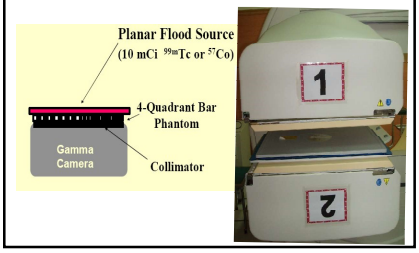
Acquisition Method

- Resolution: Intrinsic (preferred) or Extrinsic image of 5-15 million counts of four-quadrant bar phantom. matrix: 256x256.
- Linearity: Intrinsic (preferred) or Extrinsic images of 5-15 million counts with PLES or four-quadrant bar phantom. matrix: 256x256.

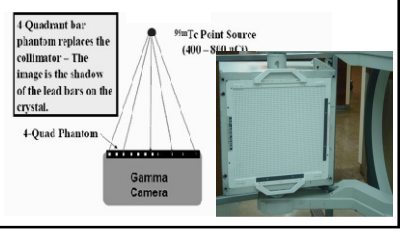
Spatial Resolution Phantoms



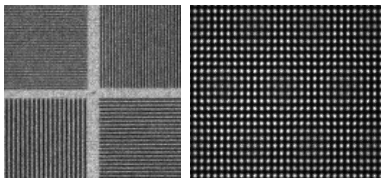
Extrinsic Spatial Resolution with Phantoms



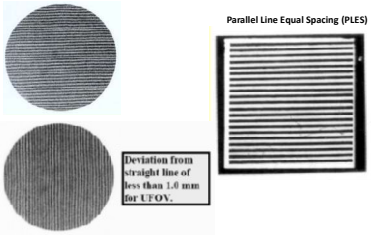
Intrinsic Spatial Resolution with Phantoms



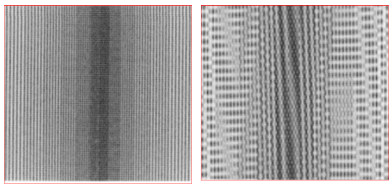
Weekly QC
Extrinsic Resolution and Linearity



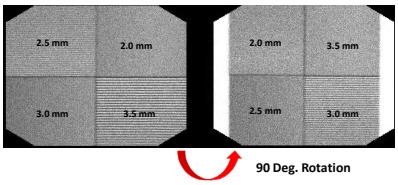
Spatial Linearity with PLES Phantoms



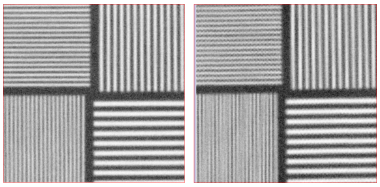
Spatial Linearity with PLES Phantoms



LEAP COLLIMATOR MEDIUM COLLIMATOR

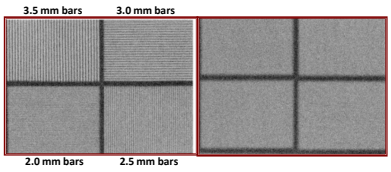


Extrinsic Resolution



LEAP COLLIMATOR MEDIUM COLLIMATOR

Extrinsic Resolution



Monthly QC

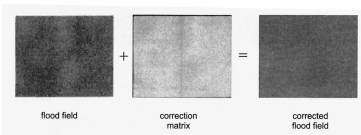
- High count calibration floods (200 million count)
- Center Of Rotation

Monthly QC

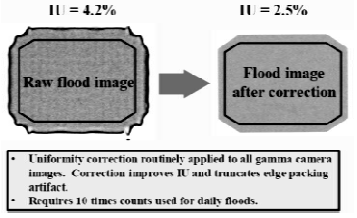
- High count calibration floods (200 million count)
- C.O.R. (center of rotation): with collimator, use 3 or 5 point source

High count calibration floods

Uniformity Correction Matrix



Uniformity Correction Improvements

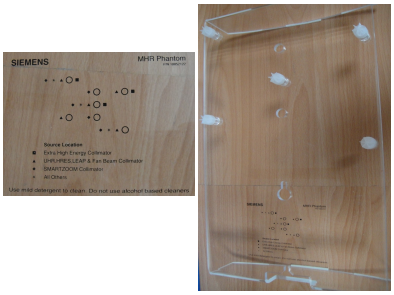


Center of Rotation

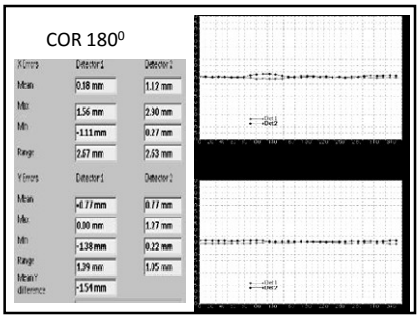
COR Acquisition is a Calibration

- Used to correct patient images
- Extrinsic calibration for both 180^0 and 90^0 detector separations
- Must follow manufacturer recommendations regarding number and placement of sources
- Sources must have sufficient activity
- Completed monthly

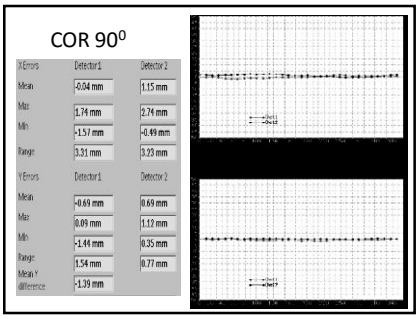
COR 180^0



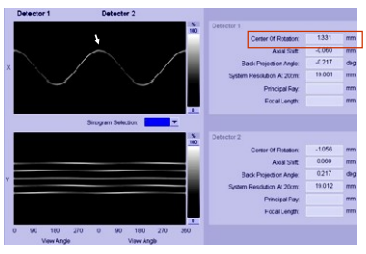
COR 180^0



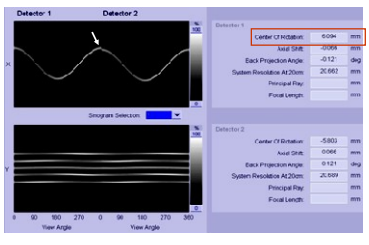
COR 90^0

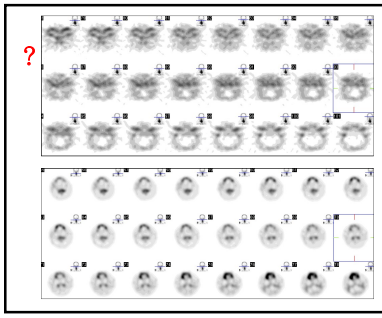


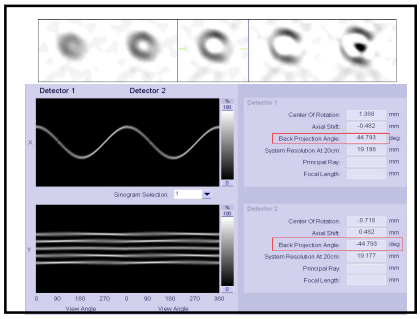
Center of Rotation

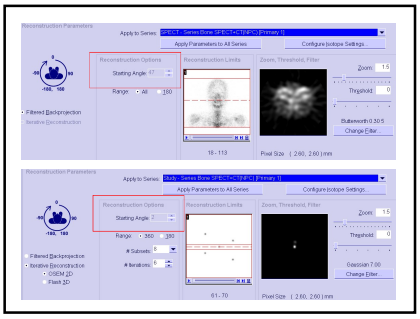


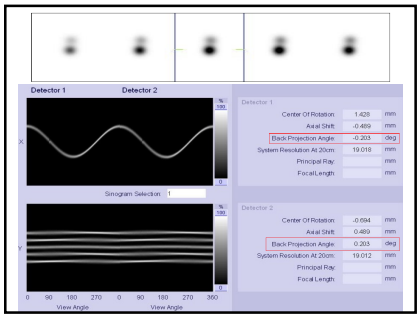
Center of Rotation



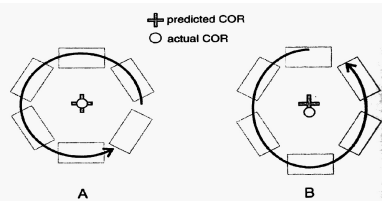




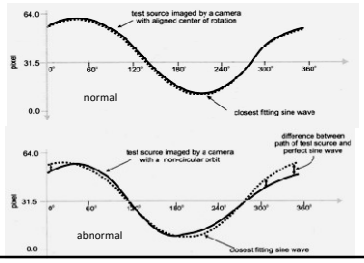




Center of Rotation Error



Center of Rotation



Donut shaped image

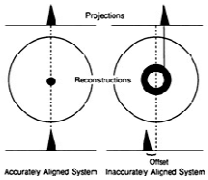


Fig. 12.11 An illustration of the effect of a misaligned center of rotation. A "donut" shaped image appears from inaccurately aligned center of rotation. (From Todd

Doughnut artifacts - COR misalignment

Correct COR

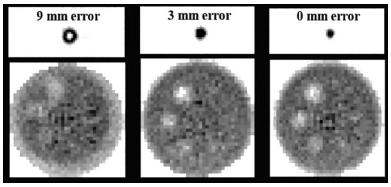
2 Pixel COR Error

Small misalignment blurring

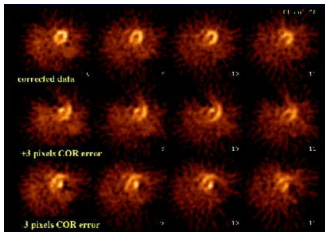
6 Pixel COR Error

Large misalignment tiny doughnut

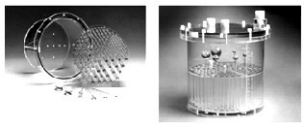
Center of Rotation Offset Error



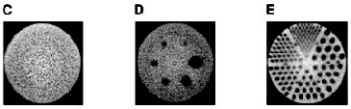
Center of Rotation Offset Error



Quarterly QC -Deluxe Jaszczak Phantom

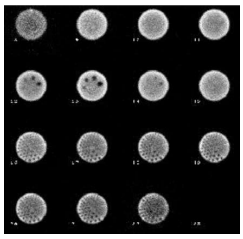


1. Used for evaluation of overall performance of tomographic imaging systems.
2. This fillable acrylic phantom is 22 cm in diameter by 19 cm in length and includes plain section.
3. Evaluation of tomographic uniformity



(C). section containing empty (cold) spheres ranging from 9.5 to 31.8 mm in diameter for evaluation of cold-sphere contrast
(D). section containing solid (cold) rods ranging from 3.2 to 11.1 mm in diameter for evaluation of reconstructed spatial resolution
(E). Images in C–E have been analytically corrected for attenuation.

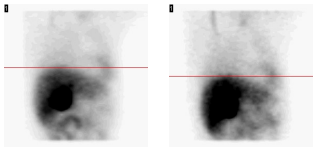
SPECT Phantom Study



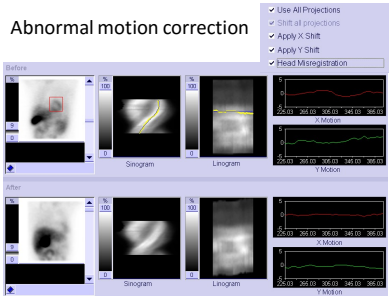
- Quarterly acquire SPECT phantom studies with 2-3 time counts obtained clinically.
- Reconstruct at highest resolution filter.
- Look for bullseye artifacts. If present, new intrinsic correction flood needed.
- Look for consist transaxial resolution. If resolution loss, acquire new COR.

OTHER

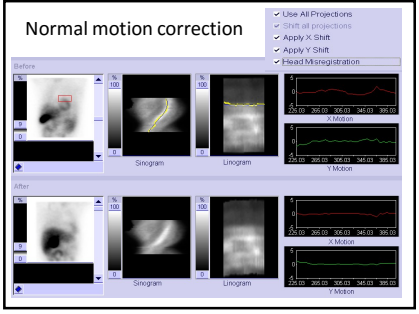
Patient motion



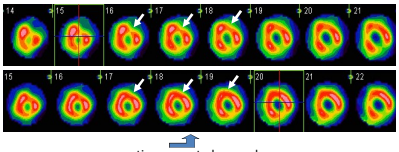
Abnormal motion correction



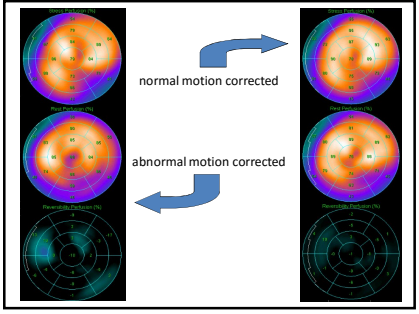
Normal motion correction



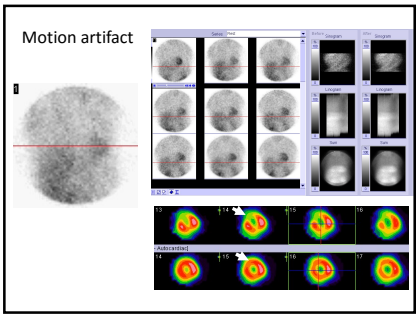
Patient Motion correction



motion corrected normal



Motion artifact



Conclusions

- Standard QC procedures for gamma cameras required in accreditation programs.
- SPECT uniformity correction and COR are camera calibrations.
- SPECT demands strict QC program.