SPECT: Acceptance Testing and QC Programs

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Thanks to Beth Harkness, Stephen Moore, and Mark Madsen
Disclosures

• ACR Accreditation Physics Reviewer
• NM Physics Consultant to several hospitals
Learning Objectives

After attending this lecture, participants will be able to:

• List 3 reasons for SPECT acceptance testing
• Define 3 tests to be performed during SPECT acceptance testing
• Describe 2 artifacts that can arise from poor SPECT quality control
• Discuss 2 tests for the acceptance testing of that may differ for dedicated cardiac SPECT units
Outline

- SPECT Calibration
- Acceptance Testing
- Routine QC including Patient Studies
SPECT Calibration

Uniformity

• Why do we need these high count floods?
• How many counts is enough?
• How often?
SPECT Uniformity

Planar nonuniformity of 4% can lead to SPECT nonuniformity of 100%!!
Nonuniformity Artifacts

Concentric Ring or “Bull’s Eye artifacts are Caused by inadequate uniformity calibration.
SPECT Uniformity: Flood Counts Needed

Need ~1% Accuracy on Flood
SPECT Calibration

Uniformity

- Need to correct pixel values to 1%
  \[ \sqrt{\frac{N}{N}} \times 100 \text{ in } \% \]
  \[ \sqrt{\frac{10^4}{10^4}} \times 100 = 1\% \]
- Thus need \(10^4\) counts per pixel
- 64x64 \(\Rightarrow\) \(~3000\) pixels \(\Rightarrow\) 30 Mcts
- 128x128 \(\Rightarrow\) \(~12000\) pixels \(\Rightarrow\) 120 Mcts
- Most sites acquire 100-200 Mct images for their uniformity calibrations
**SPECT Calibration**

**Uniformity**

- Acquire high count flood
- System corrects for uniformity either “on the fly” or during reconstruction
- Determine mean pixel count in flood image ($C_{ave}$)
- For each pixel, determine correction value

$$\text{Val} = \frac{C_{ave}}{C_i} \quad \text{where} \ C_i \ \text{is the pixel value}$$

- Correct each projection image on a pixel-by-pixel basis
SPECT Calibration

Uniformity

FLOOD WITH PENNY

UNCORRECTED

CORRECTED

Y=00037
D=00000
SPECT Calibration

Uniformity

• How often do we need to acquire these high count floods?
• Assumption is that the nonuniformities present on the day of the SPECT study are the same as your last calibration
• Depends on the stability of your system
SPECT Calibration

Uniformity

- Need 30 – 200 Mct images depending on matrix size
- Start with higher frequency (biweekly or monthly) and determine stability of your system before deciding to perform the calibration less frequently
SPECT Calibration
Center of Rotation

• The center of rotation (COR) is the point about which the projection images appear to rotate.
• It is also the reference point through which the reconstruction software backprojects.
• It is where the computer thinks the axis of rotation of the gantry is.
SPECT Calibration
Center of Rotation
SPECT Calibration
Center of Rotation
Poor COR calibration leads to a blurring of the data. It is the most likely cause of loss of resolution in SPECT.

(K. Greer, R. Jaszczak)
Center of Rotation Artifacts
SPECT Calibration

Center of Rotation

- All SPECT camera vendors have a prescribed method for calibrating the COR.
- They all involve the imaging of either a line source or a series of point sources.
- Inaccurate COR calibration is the most common reason for loss of SPECT resolution.
- COR calibration should be performed as often as uniformity calibration but this again depends on system stability.
SPECT Calibration
Detector Matching

- Popularity of Multi-Head SPECT
- Assume each head acquires the exact same data when at the same location
- Typically performed by Manufacturer’s engineers
- Users may also perform routine calibration prescribed by manufacturer which may be combined with COR calibration
- Also provides pixel size calibration
**Acceptance Testing – Why?**

- Determine if system is working as specified by vendor
- Provide baseline measurements for future comparisons
- Obtain familiarity with system
- Camera should perform well as a planar camera in order to perform well as a SPECT camera
- All planar evaluations may not be possible or appropriate for special SPECT devices
Acceptance Testing

Compared to what?

• Specifications and how they are measured are defined by the National Electronic Manufacturer’s Association (NEMA)
• Performance Measurements of Gamma Cameras (NEMA NU1 2007)
• The manufacturers should provide the NEMA specifications for their cameras upon request.
Gamma Camera
Performance Characteristics

- Performance measurements are either **intrinsic** (without collimator) or **extrinsic** (including the collimator).
- Performance characteristics may be defined in **Useful Field of View** (UFOV, defined by the manufacturer) and **Central Field of View** (CFOV, middle 50% of UFOV).
- Performance in the CFOV is typically better than over the UFOV.
Planar Performance Characteristics

- Uniformity (Intrinsic and Extrinsic)
  - System response to a uniform radiation field
- Sensitivity (Extrinsic)
  - Efficiency with which the system counts available gamma rays
- Spatial Resolution (Intrinsic and Extrinsic)
  - Systems ability to detect small objects
- Linearity or Distortion
  - Systems capability of reproducing object shapes
  - Qualitative analysis
Planar Performance Characteristics

- Temporal Resolution (Dead Time)
  - Systems maximum count rate that can be recorded
- Multiple Window Registration
  - Adequacy of energy correction of localization
- Energy Resolution (Intrinsic)
  - Ability to discern small energy differences
- Detector Shielding
  - Integrity of shielding against radiation out of the FOV
- Collimator Hole Alignment (Extrinsic)
  - Consistency of the collimator hole orientation
SPECT Performance Characteristics

- Tomographic System Alignment
  - Assure transaxial alignment and registration of multiple heads
- Tomographic Spatial Resolution
  - With and without scatter
- Tomographic Volume Sensitivity
- Tomographic Image Quality
  - Resolution, uniformity and contrast
SPECT Acceptance Testing

Tomographic System Alignment

- 3 point sources of $^{99m}$Tc at different axial positions with one on the axis of rotation
- Acquire an even number (>8) of projections, 20 cm radius
- On each projection and detector, calculate the centroid of each point in both x and y direction
- For each point, calculate COR by averaging the x centroids over all angles
- Calculate deviation for each COR and the center of the matrix \(=(N + 1)/2\)
- For multi-head, calculate the COR deviation between heads
- In axial direction (y), calculate maximum for each head and the relative misalignment between heads
**Tomographic Spatial Resolution Without Scatter**

- Use same 3 points as in System Alignment
- Radius of rotation of 15 cm
- Acquire SPECT study and reconstruct with a pixel size less than 2.5 mm
- Calculate FWHM of the point sources
- Can compare to planar system resolution at the same distance. The tomographic spatial resolution should not be more than 10% higher than the planar value
Tomographic Spatial Resolution With Scatter

- Use 20 cm cylindrical (Jaszczak) phantom
- Three line sources (one in center) and others 7.5 cm from the center in lateral and up/down direction oriented parallel to the axis of rotation
- Acquire SPECT and reconstruct with pixel size 2.5 mm
- Calculate FWHM in tangential and radial directions
Tomographic Spatial Resolution
With Scatter
SPECT Acceptance Testing
Tomographic Volume Sensitivity

- Known amount of $^{99m}$Tc (A in MBq) “empty” 20 cm cylindrical (Jaszczak) phantom with volume (V)
- Perform $360^\circ$ SPECT at 15 cm radius with 120-128 projections
- Calculate total counts (C) and elapsed time of acquisition (t)

\[
\text{Vol Sens} = \frac{(C/t)}{(A/V)} \\
\text{Vol Sens per cm} = \frac{\text{Vol Sens}}{\text{Length}}
\]
SPECT Acceptance
Tomographic Image Quality

- Image 20 cm cylindrical (Jaszczak) phantom with cold rods and cold spheres
- Evaluate uniform areas for ring artifacts
- Add 16 slices in rods together (to reduce noise) to evaluate spatial resolution
- Evaluate contrast of cold spheres
Data Spectrum (Jaszczak) Phantom
**SPECT Acceptance Testing**

**Gantry Performance**

- Full range of rotation
- Angle accuracy (spirit level)
- Head sag (spirit level)
SPECT Acceptance Testing
Secondary Evaluations

Follow-up questionable uniformity results
Ring artifacts but good planar uniformity

- Uniformity Without Corrections
- Rotational Uniformity Stability
  - Acquire floods at different angular positions
- Scatter Uniformity
  - Acquire flood through scatter
- Off-Peak Uniformity
**SPECT Acceptance Testing**

**Secondary Evaluations**

- **Tomographic Spatial Resolution**
  - Planar and SPECT imaging of line source at same distance
  - SPECT value within 10% of planar value
  - Compare heads separately

- **Phantom Reconstruction of Heads Separately**
  - Uniformity
  - Spatial resolution
## Camera Specs (Siemens e.cam)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>3/8”</th>
<th>5/8”</th>
<th>1.0”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crystal thickness</td>
<td>(segmented)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Primary Specifications</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intrinsic Spatial Resolution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FWHM in CFOV</td>
<td>( \leq 3.8 \text{ mm} )</td>
<td>( \leq 4.5 \text{ mm} )</td>
<td>( \leq 5.5 \text{ mm} )</td>
</tr>
<tr>
<td>FWHM in UFOV</td>
<td>( \leq 3.9 \text{ mm} )</td>
<td>( \leq 4.6 \text{ mm} )</td>
<td>( \leq 5.6 \text{ mm} )</td>
</tr>
<tr>
<td>FWTM in CFOV</td>
<td>( \leq 7.5 \text{ mm} )</td>
<td>( \leq 8.7 \text{ mm} )</td>
<td>( \leq 10.4 \text{ mm} )</td>
</tr>
<tr>
<td>FWTM in UFOV</td>
<td>( \leq 7.7 \text{ mm} )</td>
<td>( \leq 8.9 \text{ mm} )</td>
<td>( \leq 10.6 \text{ mm} )</td>
</tr>
<tr>
<td>Intrinsic Energy Resolution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FWHM in UFOV</td>
<td>( \leq 9.9 % )</td>
<td>( \leq 9.9 % )</td>
<td>( \leq 11.5 % )</td>
</tr>
<tr>
<td>Intrinsic Flood Field Uniformity (uncorrected)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differential in CFOV</td>
<td>( \leq 2.5 % )</td>
<td>( \leq 2.5 % )</td>
<td>( \leq 2.5 % )\textsuperscript{†}</td>
</tr>
<tr>
<td>Differential in UFOV</td>
<td>( \leq 2.7 % )</td>
<td>( \leq 2.7 % )</td>
<td>( \leq 2.7 % )\textsuperscript{†}</td>
</tr>
<tr>
<td>Integral in CFOV</td>
<td>( \leq 2.9 % )</td>
<td>( \leq 2.9 % )</td>
<td>( \leq 2.9 % )\textsuperscript{†}</td>
</tr>
<tr>
<td>Integral in UFOV</td>
<td>( \leq 3.7 % )</td>
<td>( \leq 3.7 % )</td>
<td>( \leq 3.7 % )\textsuperscript{†}</td>
</tr>
<tr>
<td>System Spatial Resolution without Scatter with LEHR Collimator at 10 cm*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FWHM in CFOV</td>
<td>7.4 mm</td>
<td>7.8 mm</td>
<td>8.5 mm</td>
</tr>
<tr>
<td>FWTM in CFOV</td>
<td>14.1 mm</td>
<td>14.9 mm</td>
<td>16.0 mm</td>
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</tbody>
</table>
## Collimator Specs *(Siemens e.cam)*

<table>
<thead>
<tr>
<th>Secondary Specifications</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intrinsic Spatial Linearity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differential in CFOV</td>
<td>( \leq 0.2 \text{ mm} )</td>
<td>( \leq 0.2 \text{ mm} )</td>
<td>( \leq 0.3 \text{ mm} )</td>
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<tr>
<td>Differential in UFOV</td>
<td>( \leq 0.2 \text{ mm} )</td>
<td>( \leq 0.2 \text{ mm} )</td>
<td>( \leq 0.35 \text{ mm} )</td>
</tr>
<tr>
<td>Absolute in CFOV</td>
<td>( \leq 0.4 \text{ mm} )</td>
<td>( \leq 0.5 \text{ mm} )</td>
<td>( \leq 0.5 \text{ mm} )</td>
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<tr>
<td>Absolute in UFOV</td>
<td>( \leq 0.7 \text{ mm} )</td>
<td>( \leq 1.0 \text{ mm} )</td>
<td>( \leq 1.5 \text{ mm} )</td>
</tr>
<tr>
<td>Multiple Window Spatial Registration</td>
<td>( \leq 0.6 \text{ mm} )</td>
<td>( \leq 1.0 \text{ mm} )</td>
<td>( \leq 1.8 \text{ mm} )</td>
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<tr>
<td><strong>Intrinsic Count Rate Performance in Air</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Count Rate</td>
<td>310 kcps</td>
<td>310 kcps</td>
<td>275 kcps</td>
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<tr>
<td><strong>Intrinsic Spatial Resolution @ 75 kcps</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>FWHM in UFOV</td>
<td>( \leq 4.1 \text{ mm} )</td>
<td>( \leq 4.6 \text{ mm} )</td>
<td>( \leq 5.6 \text{ mm} )</td>
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<tr>
<td>FWTM in UFOV</td>
<td>( \leq 7.8 \text{ mm} )</td>
<td>( \leq 8.9 \text{ mm} )</td>
<td>( \leq 10.6 \text{ mm} )</td>
</tr>
<tr>
<td><strong>Intrinsic Flood Field Uniformity @ 75 kcps (uncorrected)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differential in CFOV</td>
<td>( \leq 2.5% )</td>
<td>( \leq 2.5% )</td>
<td>( \leq 2.5%^\dagger )</td>
</tr>
<tr>
<td>Differential in UFOV</td>
<td>( \leq 2.7% )</td>
<td>( \leq 2.7% )</td>
<td>( \leq 2.7%^\dagger )</td>
</tr>
<tr>
<td>Integral in CFOV</td>
<td>( \leq 2.9% )</td>
<td>( \leq 2.9% )</td>
<td>( \leq 2.9%^\dagger )</td>
</tr>
<tr>
<td>Integral in UFOV</td>
<td>( \leq 3.7% )</td>
<td>( \leq 3.7% )</td>
<td>( \leq 3.7%^\dagger )</td>
</tr>
<tr>
<td><strong>System Spatial Resolution with Scatter with LEHR Collimator at 10 cm</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FWHM in CFOV</td>
<td>8.7 mm</td>
<td>8.9 mm</td>
<td>9.7 mm</td>
</tr>
<tr>
<td>FWTM in CFOV</td>
<td>19.1 mm</td>
<td>19.5 mm</td>
<td>20.9 mm</td>
</tr>
<tr>
<td><strong>System Planar Sensitivity with LEHR Collimator at 10 cm</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute</td>
<td>202 cpm/(\muCi)</td>
<td>225 cpm/(\muCi)</td>
<td>230 cpm/(\muCi)</td>
</tr>
<tr>
<td><strong>System Planar Sensitivity with MELP Collimator at 10 cm (ln 111)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(both energy windows at 20%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute</td>
<td>430 cpm/(\muCi)</td>
<td>565 cpm/(\muCi)</td>
<td>628 cpm/(\muCi)</td>
</tr>
</tbody>
</table>
# Camera Specs (Siemens e.cam)

<table>
<thead>
<tr>
<th>Collimators</th>
<th>LEHS</th>
<th>LEAP</th>
<th>LEHR</th>
<th>LEUHR</th>
<th>LEFB</th>
<th>MELP</th>
<th>HE</th>
<th>UHE</th>
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<tbody>
<tr>
<td>Isotope</td>
<td>$^{99m}$Tc</td>
<td>$^{99m}$Tc</td>
<td>$^{99m}$Tc</td>
<td>$^{99m}$Tc</td>
<td>$^{99m}$Tc</td>
<td>$^{67}$Ga</td>
<td>$^{131}$I</td>
<td>$^{18}$F</td>
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<tr>
<td>Hole Shape</td>
<td>Hex</td>
<td>Hex</td>
<td>Hex</td>
<td>Hex</td>
<td>Hex</td>
<td>Hex</td>
<td>Hex</td>
<td>Hex</td>
</tr>
<tr>
<td>Number of Holes (x 1,000)</td>
<td>28</td>
<td>90</td>
<td>148</td>
<td>146</td>
<td>64</td>
<td>14</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Hole Length (mm)</td>
<td>24.05</td>
<td>24.1</td>
<td>24.05</td>
<td>35.8</td>
<td>35</td>
<td>40.64</td>
<td>50.8</td>
<td>50.5</td>
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<tr>
<td>Septal Thickness (mm)</td>
<td>0.36</td>
<td>0.20</td>
<td>0.16</td>
<td>0.13</td>
<td>0.16</td>
<td>1.14</td>
<td>2</td>
<td>3.4</td>
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<tr>
<td>Hole Diameter (mm across the flats)</td>
<td>2.54</td>
<td>1.45</td>
<td>1.11</td>
<td>1.16</td>
<td>1.53</td>
<td>2.94</td>
<td>3.4</td>
<td>2.5</td>
</tr>
<tr>
<td>Sensitivity @ 10 cm (cpm/μCi)</td>
<td>1020</td>
<td>330</td>
<td>202</td>
<td>100</td>
<td>280</td>
<td>310</td>
<td>135</td>
<td>185</td>
</tr>
<tr>
<td>Geometric Resolution @ 10 cm (mm)</td>
<td>14.6</td>
<td>8.3</td>
<td>6.4</td>
<td>4.6</td>
<td>6.3</td>
<td>10.8</td>
<td>12.6</td>
<td>10.6</td>
</tr>
<tr>
<td>System Resolution @ 10 cm (mm)</td>
<td>15.6</td>
<td>9.4</td>
<td>7.4</td>
<td>6.0</td>
<td>7.3</td>
<td>12.5</td>
<td>14.5</td>
<td>19.0</td>
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<tr>
<td>Septal Penetration (%)</td>
<td>1.5</td>
<td>1.9</td>
<td>1.5</td>
<td>0.8</td>
<td>1</td>
<td>1.2</td>
<td>3.5</td>
<td>3.4</td>
</tr>
<tr>
<td>Focal Length @ Exit Surface (mm)</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>445</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Weight in lb.</td>
<td>42</td>
<td>49</td>
<td>45</td>
<td>56</td>
<td>67</td>
<td>136</td>
<td>245</td>
<td>260</td>
</tr>
<tr>
<td>Weight in kg</td>
<td>18.9</td>
<td>22.1</td>
<td>20.4</td>
<td>25.2</td>
<td>30.5</td>
<td>61.8</td>
<td>111.1</td>
<td>117.0</td>
</tr>
</tbody>
</table>
SPECT Acceptance Testing
Dedicated Cardiac Systems

• Spectrum Dynamics D-SPECT
  – 10 scanning detectors
  – CdZnTe (CZT)

• GE 530c SPECT scanner
  – 19 stationary detectors
  – 32x32 5mm CZT elements
  – Tungsten 5.1 mm pinholes

With 64 slice Lightspeed VCT
SPECT Acceptance Testing
Spectrum Dynamics D-SPECT

- Energy resolution (>7.5% at 122 keV)
- Angular registration between detectors (>98%)
- Detector homogeneity
  - Regional (>90%)
  - Global (>85%)
- Count rate performance
  - Max count rate (>1.5 Mcps)
  - Count losses (<6%)

Courtesy of Stephen Moore
Brigham and Women’s Hospital
SPECT Acceptance Testing
Spectrum Dynamics D-SPECT

Data Spectrum
Cardiac Phantom

Courtesy of Stephen Moore, Brigham and Women’s Hospital
SPECT Acceptance Testing
Spectrum Dynamics D-SPECT

Uniformity Acquisitions

Courtesy of Mark Madsen
University of Iowa
## SPECT Acceptance Testing

### Spectrum Dynamics D-SPECT

<table>
<thead>
<tr>
<th>Parameter Name</th>
<th>Detector 1</th>
<th>Detector 10</th>
<th>Detector 19</th>
<th>Acceptance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak</td>
<td>122.28 keV</td>
<td>122.27 keV</td>
<td>122.29 keV</td>
<td>122.0±1.5</td>
</tr>
<tr>
<td>FWHM</td>
<td>6.61 %</td>
<td>6.42 %</td>
<td>6.6 %</td>
<td>≤7.5</td>
</tr>
<tr>
<td>Max cluster size in primary area</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>≤8.0</td>
</tr>
<tr>
<td>Max cluster size in secondary area</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>≤16.0</td>
</tr>
<tr>
<td>Central bad pixels</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>≤30.0</td>
</tr>
<tr>
<td>Uniformity</td>
<td>6.62 %</td>
<td>5.05 %</td>
<td>6.38 %</td>
<td>≤9.0</td>
</tr>
</tbody>
</table>

![Detector Energy Curves](image1)

**Courtesy of Mark Madsen**
**Univ of Iowa**
Routine SPECT QC

- **Planar QC**
  - Floods (intrinsic or extrinsic, daily)
  - Bars (spatial resolution, weekly or monthly)

- **SPECT QC**
  - Tomographic phantom
  - Clorox bottle and capillary tube

- **Patient QC**
  - Sinograms
  - Summed image
  - Cine
**SPECT QC**

**Overall Performance with Tomographic Phantom**

- Perform this evaluation quarterly
- Data Spectrum ("Jaszczak") SPECT (or other) phantom with cold rods and spheres
- Fill with 20-30 mCi of Tc-99m
- Place at end of table parallel to the axis of rotation
- 20 cm radius of rotation, 500 kcts per projection
- Reconstruct with Hann filter with 1.0 Nyquist cutoff
- Qualitatively evaluate tomographic uniformity and resolution and determine contrast as described earlier
Data Spectrum (Jaszczak) Phantom
Data Spectrum (Jaszczak) Phantom

Ring artifact
**COR Calibration**

½ Pixel COR Shift  
Corrected

IAEA Gamma Camera QC Atlas
Data Spectrum (Jaszczak) Phantom
Dual Headed Camera
Dual Headed Camera
Detector 1
Clorox Bottle and Capillary Tube

- These can be used as a cost-effective alternative to the high-cost tomographic phantoms
- Place several mCi of $^{99m}$Tc in Clorox bottle filled with water and image as if a brain. Look for ring artifacts.
- Capillary tube (butterfly taped to ruler) with $^{99m}$Tc on table parallel to axis of rotation. Acquire planar image at same distance (20 cm). Reconstruct SPECT and determine FWHM of both planar and SPECT. The SPECT should not be more than 10% higher than planar.
Routine Patient QC

- Rotating cine of projection images
- Sum of projection images
- Sinogram
- Review of final, reconstructed images
Routine Patient QC
Sinogram

Stack of projections of a particular slice as a function of projection angle.
Routine Patient QC
Projection Cine Display

MIP
Cine of Projection Images
For QC, these are what we want!!
Routine Patient QC
Sinogram

Patient sat up during SPECT acquisition

Summed Projections
Routine Patient QC
Sinograms

SPECT Camera Malfunction
Routine Patient QC
Sinograms

Axial Motion
Routine Patient QC

Original Slices

Corrected for Axial Motion
Routine Patient QC

Liver/Spleen SPECT with Ring Artifact
Questions?