Gamma Camera Characteristics

Purpose: To introduce basic characteristics of a gamma camera, by measuring two gamma camera performance parameters. This lab will assess changes in spatial resolution and sensitivity of the gamma camera as a function of source-to-collimator distance and collimation type (LEHR versus MELP).

Equipment:
• 4 Siemens dual-head gamma cameras with 4 unique combinations of crystal thickness/collimation
  • 3/8” crystal and LEHR collimator
  • 5/8” crystal and LEHR collimator
  • 3/8” crystal and MELP collimator
  • 5/8” crystal and MELP collimator

Materials:
• Radioactive Sources:
  - Tc-99m: 2 line sources (1.2 mm ID, 0.5 cc) containing ~1 mCi $^{99m}$Tc each
  - Tc-99m: 2 flat-bottom flasks containing a thin layer of 100-150 µCi $^{99m}$Tc (calibrated)
• 2 foam blocks of similar thickness (~10 cm) for suspending a line source between the 2 detectors
• 2 foam flask holders (~10 cm height) for suspending a flask between the 2 detectors

I. Extrinsic Spatial Resolution

Task: Measure the extrinsic (a.k.a. system) spatial resolution of the gamma camera (FWHM, in mm) with a specific crystal thickness and collimation combination assigned to your group. Spatial resolution will be measured at 4 different source-to-collimator distances. Two separate data acquisitions will be performed as shown in Figure 1.

Steps for Data Acquisition:
1. Create a patient/study on the scanner
   Name: zpaf_medphys4_Lab, Ext Spatial Res
   ID: today’s date (MMDDYYYY)
   Study: Calibrations
2. With that patient selected, launch (by double-clicking on) the acquisition workflow
   Category: Physics
   Workflow: Static Acq for MedPhysIV Lab6 Spatial Resolution
   Series name: Static Acq of Tc99m line source <collimator>
   (replace <collimator> with LEHR or MELP, depending on which is installed)
3. Verify (Which, if any, of these parameters is important for this measurement?)
   Analyzer Preset (energy window): Tc99m-NMG
   Matrix Size: 1024×1024
4. Orient camera heads 1/2 in the 0/180 degree configuration with head 1 at top-dead-center. Place a chux on top of the bottom collimator face (detector 2) to prevent radioactive contamination of the camera head.

5. Move the detector heads radially so that the distance between the two collimator faces is \(3x = \sim 31.5\, \text{cm}\), where \(x \sim 10.5\, \text{cm}\) accounts for the line source phantom’s 0.5 cm outer radius. (Tip: Adjust the radial position of each head so the collimator face radius reading on the scanner’s persistence monitor is \(\frac{1}{2}\) that value.)

6. Setup Figure 1a: Gently place the line source directly on the collimator face near the center of the field-of-view (FOV) of detector 2, and oriented it along the short axis of the FOV (i.e. along the bed). Record the vertical distance of the center of the line source from each collimator face. (Why is this measurement important?) Measure the distance from a lateral edge of the detector FOV to the line source at both axial ends of the FOV, to make sure they are parallel. (Why is the orientation important?) Acquire a 10 min scan.

7. Setup Figure 1b: Place the foam block on the collimator face of detector 2 and the line source on top of the foam block. Again, orient the line source along the short axis near the center of the FOV; record the vertical distance of the center of the line source from each collimator face; and measure the distance from a lateral edge of the detector FOV to the line source at both axial ends of the FOV, to make sure they are parallel. Acquire a 10 min scan.

8. Select the acquired image series and launch the analysis workflow

   **Category:** Processing Activities  
   **Workflow:** Series ROI Curve Generic Proc

9. Click on the **ROI Tool** icon and draw 5 approximately evenly-spaced line ROIs along the axial extent of line source on the first (first acquisition, head 1) image. (Hold the Shift key down to ensure that the lines are exactly horizontal on the image). Click **OK** to save the lines. (The lines will be saved on both the first, head 1, and second, head 2, images from the first acquisition.) Next, one at a time, select a line, create its line profile and compute its FWHMs by clicking the **FWHM** icon; and repeat for the second image. (Tip: It is best to delete each line profile created once you have recorded the FWHM. Otherwise, the graph gets a bit “messy”.) Then select the third, head 1, image and repeat the entire above analysis process. Finally, record all FWHM data together with crystal thickness and collimation type.

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**Figure 1:** Schematic setup for spatial resolution measurements (Section I), \(x \sim 10.5\, \text{cm}\) to center of line source (accounting for line source phantom’s outer radius, given an \(\sim 10\, \text{cm}\) thick foam block).
Share your measurements with the other three groups, so that each of you has extrinsic resolution values measured at 4 different distances for all 4 unique combinations of crystal thickness and collimation.

Each group is to submit a report of the results of the extrinsic spatial resolution measurements for all crystal thickness/collimator combinations:

1. Plot the FWHM vs. source-to-detector distance for each combination
2. Characterize and discuss the overall change in spatial resolution of the gamma camera at 140 keV (Tc-99m) with distance, crystal thickness and collimation.

(For the purposes of this lab, it is assumed that the performance of both detectors and collimators on a given scanner is the same. Is this reasonable?)
II. Sensitivity

Task: Measure the sensitivity of the gamma camera (in [cpm/μCi]) with a specific crystal thickness and collimation combination assigned to your group. Sensitivity will be measured at 4 different source-to-collimator distances. Two separate data acquisitions will be performed as shown in Figure 2.

Steps for Data Acquisition:
1. Create a patient/study on the scanner
   - **Name**: zpaf_medphys4_Lab, Sensitivity
   - **ID**: today’s date (MMDDYYYY)
   - **Study**: Calibrations
2. With that patient selected, launch the acquisition workflow
   - **Category**: NM Testing
   - **Workflow**: Tc-99m sensitivity Acquisition
   - **Series name**: Tc99m sensitivity <collimator> distance
     (replace <collimator> with LEHR or MELP, depending on which is installed)
3. Verify (Which, if any, of these parameters is important for this measurement?)
   - **Analyzer Preset** (energy window): Tc99m-NMG
   - **Matrix Size**: 256×256
   - **Zoom**: 1.0
4. Orient camera heads 1/2 in the 0/180 degree orientation with head 1 at top-dead-center.
   Place a chux on top of the bottom collimator face (detector 2) to prevent radioactive contamination of the camera head.
5. Setup Figure 2a: Place the flask horizontal and directly on the chux at approximately the center of detector 2’s FOV. The source-to-collimator face is ~0 cm. Adjust the radial position of head 1 so that its detector collimator face is at a distance of ~30 cm from that of detector 2. (Tip: Adjust the radial position of each head so the collimator face reading on the gantry monitor is 15 cm.) Acquire a 3-phase, 1 min/frame dynamic study and record the start time of day (hh:mm) of the first dynamic frame of the sensitivity flask. (Each subsequent dynamic frame of the flask will be exactly one minute later than the previous.)

   **NOTE**: The dynamic study is three-phase, with a pause after each phase:
   - Phase 1: one 1-min frame (background)
   - Phase 2: ten 1-min frames (sensitivity flask)
   - Phase 3: one 1-min frame (background)

   **IMPORTANT**: A first background acquisition must be performed prior to bringing the flask into the scan room and positioning it on detector 2. When the first-phase 1-min background acquisition has finished, carefully position the flask and start the second-phase, ten 1-min frame dynamic acquisition. When the second phase has finished, carefully remove the flask from the room and start the third-phase 1-min second background dynamic acquisition. The average of each detector’s two background image total counts are to be used for background correction in the calculation of system sensitivity.

6. After all three phases have been completed, select the Display/Analysis tab; and then select the “statistics” icon (Σ) at the bottom of the screen to enable display of total image counts.
Click on each image and record the total number of counts. Note: the twelve frames from
detector 1 (first background, ten flask, second background) are displayed first, followed by
those for detector 2.
7. Setup Figure 2b: Place the flask horizontally in the foam holder at approximately the center of
the FOV of detector 2. The source-to-bottom collimator face distance will be ~10 cm and the
source-to-top collimator face will be ~20 cm. Repeat steps 2 to 6.

![Diagram of setups](image)

**Figure 2:** Schematic setups for sensitivity measurements (Section II), x~10cm.

8. Sensitivity calculation (for each distance)

1. Calculate the average of the two background image total counts, background-correct each
measured flask image total count value, and compute the mean of the 10 net total count
values [cpm].
2. Decay-correct the flask activity [uCi] from its assay time of day to the time of day of the 5th or
6th frame (or the mean time of day) of the ten 1-min flask dynamic acquisition; and
compute system sensitivity [cpm/uCi].
3. Plot the sensitivity vs. source-to-detector distance, for each crystal
thickness/collimator combination.
4. Characterize and discuss the overall change in sensitivity with distance, crystal
thickness and collimation.

Share your measurements with the other three groups, so that each of you has sensitivity values
measured at 4 different distances for all 4 unique combinations of crystal thickness and
collimation.

Each group is to submit a report of the results of the sensitivity measurements for all crystal
thickness/collimator combinations.
Date: 

Group Members: 

Camera Name: 
Crystal Thickness: 
Collimator: 

Extrinsic Spatial Resolution Data

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Sensitivity Data

Source Activity: 
Assay (Calibration) Time of Day: 

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