Experiment Notebook Format

Experiment Notebooks will be distributed during the first weeks of the second Quarter.

Quarter 2 experiments to be completed:

Lab A: Count Rate, Time and Distance
Lab B: Determine the chemical purity of Tc^{99m} MDP and Tc^{99m} MAA
Lab C: Calculate Actual and Theoretical dead time
Lab D: Spatial Resolution

Format

Typewritten report must include:

1) Title Page with Name and Date(s) of Experiment
2) Table of Contents
3) Experiment Body to include:
   - Purpose
   - Description of Procedure
   - Materials/Equipment Used
   - Technique
   - Data
   - Graphs or Films (Most systems allow you to right-click on an image to save a digital copy to disk)
   - Discussion of Data
4) Conclusion

These experiments are designed for independent study but should always involve appropriate supervision from clinical support staff. Experiments can be completed at any institution. Labs are to be done as time permits and must not interfere with the department's responsibility to patient care. These experiments are time consuming so plan accordingly.

Experiment Notebook
Quarter 2 – Lab C
Dead Time

References: http://hps.org/publicinformation/ate/q1024.pdf
Sodee: p. 157 - 158

Format: Typewritten report must include

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   - Purpose
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4. Conclusion

Dead Time

These experiments are to be completed under the supervision of a licensed technologist within the affiliate's nuclear medicine department. Experiments shall not interfere with clinical duties.

BACKGROUND

Dead time is the interval immediately following the observance of an ionizing event. During this time a radiation detector cannot respond to another ionizing event. The duration of insensitivity is also referred to as resolving time. In GM tubes the occurrence of dead time is the result of the inability of the already ionized gas molecules to produce a separate pulse until after they recombine. Resolving time in a GM survey meter can run as high as 200 μ sec.

Scintillation cameras also have an analogous dead time (also known as non-paralyzable dead time). This time is much shorter than that in a gas detector and results primarily from the duration of the pulse produced by the photomultiplier tube. A second event occurring before the completion of the pulse from the first event results in a mere lengthening of the pulse produced by the photomultiplier tube. Known as “pulse pileup”, two or more absorbed events are summed into one discrete pulse and therefore one count. Resolving time for scintillation detectors, however, is so short (10 μ sec) that accurate counting is more likely a limitation of the response speed of the electrical or electromechanical counting mechanisms.

INTRODUCTION

Given the influences of dead time on an instruments observed count rate, it is advantageous to determine the resolving time occasionally. Drastic changes may suggest component failure while subtle changes may impact efficiency (especially at higher count rates). The most common mathematical model used to determine the True Count Rate is the nonparalyzable dead time model. This model assumes that any interactions of ionizing particles that occur in the detector during the dead-time interval do not influence the magnitude of the dead time. However, when count rates are high, and dead time losses exceed 30%, a paralyzable model must be employed. This method however involves a cumbersome iterative or graphical process used to solve directly for the true interaction rate.

OBJECTIVE

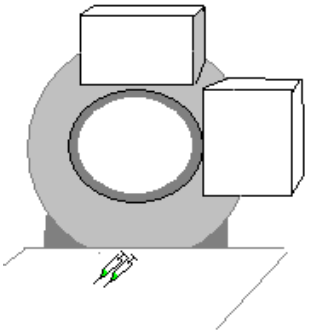
Determine the dead time of a scintillation camera system using a paired source.

MATERIAL

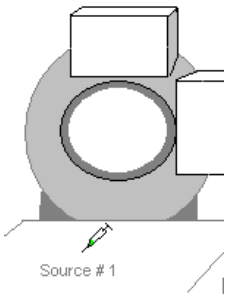
1. Scintillation camera.
2. Paired source (e.g. Two syringes containing ~500 μCi of pertechnetate, each). The greatest challenge of this experiment will be to draw equivalent amounts into each syringe. Exceeding 500 μCi is okay, as long as both syringes are approximately equivalent to one another.

PROCEDURE

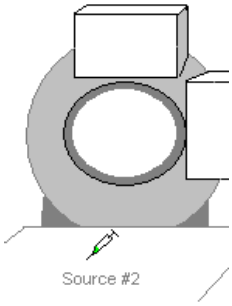
1. Draw two paired ^{99m}Tc sources containing approximately 500 µCi each. Note that a variation of more than 20 µCi between syringes may adversely affect the results. Be sure to label the syringes for later identification. To avoid contamination, place the syringes inside a latex glove when transporting and counting.
2. Remove the collimator from the detector.
3. Raise the camera to its highest position (on a 2 headed system you may have to orient the camera heads in "L" mode to avoid interference from the 2nd head).
4. Center the paired sources beneath camera on the floor (see note in red below).
5. Count for a total of 5 million counts (This shouldn't take more than ~30 sec or so).
6. Record the time taken to do so (Repeat at least 3 times).
7. Shield one syringe and count source #1 by itself for 5 million counts.
8. Record the time taken to do so (Repeat at least 3 times).
9. Repeat step 7 for the second syringe by itself.
10. Record the time taken to do so (Repeat at least 3 times).



Step 4 (paired source)



Step 7



Step 9

IMPORTANT: With newer cameras, it is better to position the source about 10 feet away (taped to a wall or suspended off a shelf in a glove). Doing so will produce a greater separation in the count time for each individual source versus the paired source. Be sure to place each source in the same spot for each count.

DATA

5 Million Counts	Activity	Time Trial 1	Time Trial 2	Time Trial 3	Average Time
Paired Source	µCi	sec	sec	sec	sec
Syringe 1 alone	µCi	sec	sec	sec	sec
Syringe 2 alone	µCi	sec	sec	sec	sec

DATA TREATMENT

1. Calculate the following rates based on data collected:

   Counts-to-time ratio: "R_{12}" = 5 million counts / the average time for the paired source
   Counts-to-time ratio: "R_1" = 5 million counts / the average time for Syringe 1 alone
   Counts-to-time ratio: "R_2" = 5 million counts / the average time for Syringe 2 alone

2. Calculate Dead time of the scintillation camera using the following formula:

   Dead Time (T) = $\frac{R_1 + R_2 - R_{12}}{2\,(R_1 \times R_2)}$ (Hint: watch your units!!!)

3. Consider a source that produces an observed count rate of 10,000 cpm. Using the nonparalyzable (Scintillation camera) detector model below and the dead time calculated above, determine the true count rate.

True Count Rate (R_t) = $R_o\left(\frac{RoT}{1 - RoT}\right) + R_o$

R_o = Observed count rate of 10,000 cpm
(Hint: Consider converting to cps)

T = Dead Time as calculated above

4. Why would you expect a higher value when using a GM counter (e.g. Paralyzable System)?

5. Determine the percentage of all events measured by your scintillation camera.

   Percent Counting Efficiency = $100(1-R_{12}T)$.

6. Explain how dead time reduced the counting efficiency of the paired source.

7. Explain the difference between paralyzable and nonparalyzable dead time.

CONCLUSION

What lessons can be learned from this experiment? What was the point of comparing the count rate of the paired source with each individual count rate?