

ABR 16-Month NM Pathway – Problem Set 5: PET and PET/CT

Required Readings:

- ☐ RSNA Physics Module: Atoms, Radiation, & Radioactivity
- ☐ Essentials of NM Physics, Instrumentation, and Radiation Biology (Powsner)
 - Chapter 8 – Positron Emission Tomography (PET)
 - Chapter 11 – Hybrid Imaging Systems: PET/CT, SPECT/CT, and PET/MRI

1. Circle the best answer from the choices below. PET scanners detect:

- a. Positrons of the same energy in coincidence.
- b. positrons and electrons in coincidence.
- c. Photons of different energies in coincidence.
- d. Annihilation photons in coincidence.
- e. Annihilation photons with different time stamps.

2. Explain 2D versus 3D PET.

3. Explain Time of Flight (ToF)

4. The figure below depicts four coincidence events (labeled as a, b, c, d) possible in PET. What are these called? Describe them.

- Two 511 keV photons arising from a single annihilation event striking opposing detectors simultaneously.
- Two 511 keV photons arising from separate annihilation events striking opposing detectors simultaneously.
- One 511 keV photon from a single annihilation event strikes a detector, and the other is absorbed by surrounding tissue.

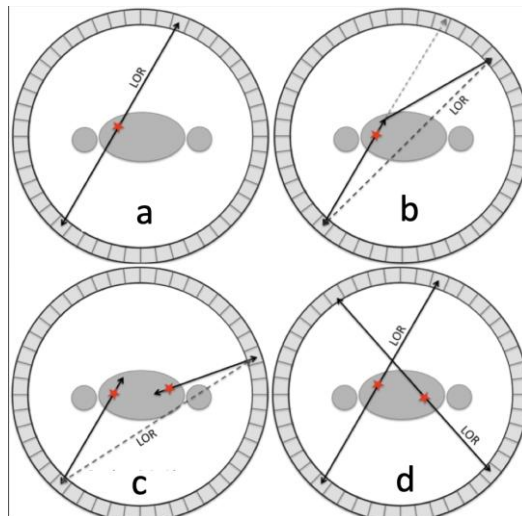
Choices: Single event, random event, true coincidence event.

a.

b.

c.

d.



5. True or False and explain why:

- a. In PET no collimator is needed to determine the line of response for a given decay.
- b. Energy resolution of detectors used in PET is better than that in SPECT.
- c. Light output affects the crystal's energy resolution.

6. Thicker crystal yields better energy resolution but worse spatial resolution. Which of the following characteristics are desirable for the scintillator material used to detect 511 keV photons? Circle the correct answer(s).

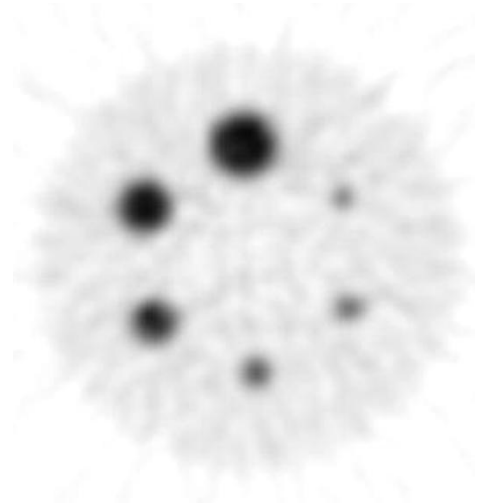
- a. Low density.
- b. High atomic number.
- c. Long decay time.
- d. High light yield.

7. True or False: Which of the following is / are true regarding PET?

- a. PET is the acronym for Positive Emission Tomography.
- b. When a positron combines with a negatron (negative electron) during annihilation their rest mass energy is converted into two 511 keV photons emitted exactly 180 degrees to each other.
- c. One limitation to the spatial resolution in PET is the distance the positron travels after being emitted before it annihilates.
- d. In 3D PET the axial septa used in 2D PET are removed thereby increasing the sensitivity at the expense of higher scatter.

8. True or False: Which of the following is / are true regarding PET imaging?
- a. Most current PET systems use BGO as the detector of choice because of its excellent attenuation of the 511 keV photons employed in PET.
 - a. Accidental or random coincidences are when both of the 511 keV photons emitted when the positron annihilates are not detected at all by the ring of detectors.
 - b. The loss of one detector results in a diagonal line of lost coincidence pairs in the sinogram.
 - c. In PET imaging TOF is the abbreviation for Transmission Of Flux of the 511 keV photons.
9. True or False: Which of the following is /are correct regarding attenuation and attenuation correction in PET?
- a. Because 511 keV photons are being imaged, attenuation is much less of a problem in PET than in SPECT where 140 keV photons are being imaged.
 - b. In the absence of attenuation correction structures towards the center of the patients appear to have higher concentrations of activity than they should.
 - c. CTs are added to PET systems to provide attenuation maps for attenuation correction and anatomical context for localization of activity in the PET study.
 - d. With CT based formation of attenuation maps one should consider the possibility of motion between CT and PET imaging and the resulting mismatch of the attenuation maps causing artifacts.

10. The image shown here is from a tomographic phantom with “hot”, spherical features mimicking tumors with varying diameters (12 to 33 mm) and with the same F-18 activity concentrations (kBq/mL). The tumor-to-background ratio is of about 4 to 1.



- Why do the different sized tumors appear as different intensity?
- Is the contrast of small spheres or large spheres affected more by finite spatial resolution?
- How does this phenomenon affect quantification of these features?
- What aspect of the PET scanner would have to be substantially improved in order to alleviate this phenomenon?

11. Name two factors that affect spatial resolution in PET. For each factor, please indicate how you might (if possible) reduce its impact.

12. A cylindrical phantom A is filled with ^{99m}Tc and imaged with SPECT whereas an identical cylindrical phantom B is filled with ^{18}F and imaged with PET. Assuming identical scan sensitivities, both phantoms acquired projections are reconstructed in an identical way. Which reconstructed volume is affected more by attenuation, A or B?

13. How does TOF improve PET image quality? Circle the correct answer(s).

- a. Improve spatial resolution
- b. Improve sensitivity
- c. Improve signal-to-noise ratio in large patients
- d. Increase noise

14. Artifacts in hybrid imaging can occur as the result of which of the following? Circle the correct answer(s).

- a. Breath holding following deep inspiration during CT acquisition followed by normal breathing during PET or SPECT acquisition.
- b. Attenuation correction of PET images with contrast CT images.
- c. Patient movement between the CT and PET scans.
- d. All of the above.

15. What are some of the advantages of using a hybrid imaging system? Circle the correct answer(s).

- a. Misregistration as a result of patient motion is reduced, as the patient remains on the same imaging pallet (bed) during acquisition of both the CT and the PET or SPECT images.
- b. The CT images can be used both for attenuation correction of the PET or SPECT images and for localization of the PET or SPECT image findings.
- c. All of the above.